THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 55 — Thursday, December 10, 1936 — No. 1060

PUBLISHED WEEKLY

Subscription Terms: 15s. per annum.
Foreign and Colonial: 17s. 6d. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL,
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address: "Zacatecas, Rand, London."
Telephone: Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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Interlocking Industry

The annual dinner of the British Ironfounders' Association and its associated employers' federations was this year outstanding, inasmuch as definite propaganda was made for interemployer-federation co-operation. Moreover, a distinct lead was given as to exactly how such co-operation could be effected. The scheme, very ably propounded by the principal guest, Sir Alfred Hurst, amounts to the institution of interlocking agreements between the builders' merchants and the various manufacturers of the materials they handle. This would mean that if either a manufacturer or a merchant broke an agreement, resulting in the creation of an uneconomic price level for any one type of material handled by a builders' merchant, then pressure could be applied by a number of interests, with the attitude that price cutters are a danger to the industry as a whole. Moreover, such a combination as is envisaged could, without Government interference, regulate the import market and at the same time make its power felt in the export trade. A great advantage of such a scheme is that it allows the various firms to develop individually, pay decent wages, and create a reserve for modernisation and expansion within the absorption power of the market.

Sir Alfred wisely drew attention to the alternative to co-operation by interlocking agreements, and referred to conditions in Germany, Russia and Italy. To our mind, he should have included Japan also. In all these countries, both employer and workman have to sink their individual aspirations to the exigencies of the State. The existence of wages agreements and arrangements with merchants are to-day insufficient for the conduct of an industry. The superimposing of interlocking agreements strengthens the position of both parties enormously, as any merchant would hesitate to introduce price cutting if the whole of his supplies were thus jeopardised, whilst a manufacturer on his side would hesitate to countenance such action if the major market for his goods might be detrimentally affected. Such agreements as we have mentioned are well capable of being horizontally as well as vertically expanded. Such methods seem a little "comic" for old-fashioned businessmen, but with the present enormous manufacturing capacity of the world and the delicate nature of the markets, we feel certain that of all methods available for preventing periodic industrial chaos, this is the best so far devised.

Shortage of Men

Our remarks last week on the shortage of leading men in the industry apply equally to the shortage of skilled labour for the actual work of the foundry. It is well known that the smallness of the number of young people entering the industry as apprentices is causing serious concern, and quite recently Germany has compelled its works to absorb a certain proportion of apprentices. Compulsion of this kind cannot be entertained in this country, and the only way open is to make the conditions of employment sufficiently attractive to induce young men to take up the trade. It has been a commonplace for years that the quality of the youths entering founding is lower than that of those entering the engineering trades, for such occupations as fitting, turning, and so on, and is indeed lower than the quality of youth entering patternmaking. Fathers who are moulders are less willing than they were that their sons should follow in their trade, and consequently the calibre of entrant is bound to diminish.

Some of the reasons for this state of affairs may be based on misunderstanding, but others are not, and the industry has to compete for a diminishing supply, on account of the falling birth rate, against occupations of a new kind which offer attractions of their own, as in the distributive trades and in the new industries which have sprung up in recent years and which appeal to boys. How the balance is to be restored is too big a question to be considered in a few lines, but, generally speaking, the industry stands to lose in the long run if the intelligence of its operatives diminishes. Many shop troubles can be avoided if the man on the job understands more about it. The more intelligent type of youth will be attracted by a definite opportunity to learn the trade, by the possibility of chances of promotion to the limit of his capacity, and by recognition of merit. The immediate results of a less enlightened policy place the more progressive and enterprising firms at such disadvantage that any forward steps should be taken for the trade as a whole.

The Ceramic Society

REFRACTORY MATERIALS SECTION

At the Autumn Meeting of the Ceramic Society, held in London recently, various Papers were presented to the Refractory-Materials Section. Below we give abstracts of the more important.

Properties of Magnesite and Chrome-Magnesite Bricks

BY J. H. CHESTERS AND L. LEE.

The melting point of silica being 1,729 deg. C., and the normal operating temperature of a basic open-hearth furnace about 1,650 deg. C., the working margin is so small that an accidental rise in the operating temperature or deflection of the flame soon destroys the roof, and it is only recently that a suitable basic refractory for an open-hearth furnace roof has been provided. The high refractoriness under load, and absence of after-shrinkage, in spite of a spalling tendency, low resistance to certain slags, and its relatively low-melting point, have enabled silica to be used with considerable success. Magnesite and chrome-magnesite bricks have been greatly improved within recent years, and some special refractories highly resistant to spalling have been developed, and many all-basic furnaces are in operation.

Results of tests made by the authors on properties of various magnesite, chrome-magnesite, and silica bricks are shown in tables and graphs, the properties tested including porosity, bulk density, specific gravity, permeability, cold crushing strength, after-shrinkage, refractoriness under load, softening temperatures and thermal expansions. Microscopic appearances of thin sections are described, with illustrations. Tests for spalling resistance and slag resistance were also made. Mixture of fluorspar and magnesite have much lower melting points than corresponding mixtures of basic slag with magnesite, which accounts for the serious cutting action of fluorspar on basic refractories. Of the bricks examined, only two—one British and one Continental—were found to have sufficiently high spalling resistances and refractoriness under load, along with absence (or nearly so) of after-shrinkage to justify a trial in an open-hearth furnace roof. Both of these bricks (as well as three of the other four tested) consist essentially of about 75 per cent. chromite and 25 per cent. magnesite (the magnesite being in finely-divided condition) and a forsterite bond.

It was pointed out that as the important point in connection with the expenditure on refractories is the cost per ton of steel produced, the comparatively high cost of better refractories may be compensated by longer life and less frequent need for repairs, coupled with increased output.

Mechanical Properties of Refractory Materials

BY A. L. ROBERTS, PH.D.

By the mechanical properties is meant the factors which govern resistance to applied stress, or which may be concerned in internal stress; they include the modulus of elasticity, the ultimate strength under different types of stress, and the "flow" characteristics which become important in the development of plasticity in material stressed at appropriate temperatures.

Refractory materials at high temperatures lose the property of almost perfect elasticity, and tend to become plastic at temperatures far below the fusion point. This transition temperature in the case of fireclay and fireclay-silica mixtures lies in the range 800 deg. to 1,000 deg. C. The transition from elasticity to plasticity makes it difficult to measure satisfactorily at higher temperatures such properties as the modulus and ultimate strength.

When a material is stressed within the elasticity range, the strain (or deformation) is proportional to the stress up to the breaking stress, but not beyond it. When the material is hot enough to be plastic, it may not show a constant deformation under constant stress (as it does in the elastic state), but "flows," the deformation increasing continuously with the time. If in such case the stress is removed, the original form may not be completely restored (as it would be in the elasticity range), but some permanent distortion may remain.

Much systematic study of the flow characteristics of refractory materials and of ceramic bodies in general is necessary.

The refractoriness-under-load test is valuable as a relatively rapid means of examining or comparing the behaviour of refractory materials, but it gives only limited information and the test piece being subjected simultaneously to both stress and a rising temperature, the true effect of the stress on the material at any given temperature may not be indicated by the deformation curve obtained.

These and other considerations suggest the need of a systematic investigation of the relations between stress, temperature, and deformation of refractory materials. Reference is made to results obtained by A. J. Dale, F. H. Clews, and A. T. Green in compression tests on refractory materials.

Other topics discussed include restricted expansion stresses, and indirect stress, or stress of internal origin in refractory materials, the latter being examined at considerable length.

The authors' summary and conclusions are as follow (slightly abridged):—The evaluation of the mechanical properties over a wide range of temperature cannot be carried out by a single method of testing. Up to a certain limiting temperature (about 1,000 deg. C. in the case of refractories of the fireclay type), above which the materials lose the characteristics of almost perfect elasticity, the usual methods of measuring the mechanical properties are applicable. In this temperature range interest centres on the modulus of elasticity (in shear or tension) and the corresponding ultimate strength, the ratio $\frac{\text{modulus}}{\text{ultimate strength}}$ being a criterion of the influence of the mechanical factors on the tendency to spall of the material. The temperature range of incipient plasticity, shown by the falling of the modulus, is an important property, indicating the temperature at which the liability of the material to fail under stress by cracking or spalling will be replaced by the tendency to accommodate stress by internal adjustment ("stress release"), which will give rise to warping as the fault induced. Above this temperature range the measurement of modulus and ultimate strength becomes impossible, as the deformation of the materials at a given temperature depends then not only on the stress but also on the time of application of the stress. Logical tests in the higher temperature range (plastic range) must therefore include time as a variable.

The complete investigation of the relations between stress, deformation, temperatures and time, for typical refractories, etc., is a great task, probably best undertaken by co-operative effort, but its results would be of permanent value.

Spalling of Fireclay Bricks

BY H. D. BENNIE.

"Spalling," in reference to refractories, is not easy to define briefly, because it is used to indicate several different forms of disintegration. One conception is that spalling is the breakdown of the structure of a firebrick or of brickwork, resulting from irregular mechanical strength of the brick or brickwork when subjected to thermal shock. The average firebrick is far from regular within its structure as regards mechanical strength. This fact is well illustrated by the cold crushing strength reported for 20 similar bricks taken at random from stock. The crushing strength ranged from 2,542 to 3,987 lbs. per sq. in. Lantern slides served to show moulding flaws, air cavities and lamination in bricks. Another kind of spalling is the splitting away of the fused surfaces of bricks exposed to very high temperatures and cooled very suddenly. Yet another case is the splitting away of that layer of a firebrick lining which has become impregnated with glass, slag or metal. In this case the spalling results from slag penetration and should be treated as a different problem. The author suggests that spalling should be considered solely as the inability of a brick or brick construction to withstand cycles of temperature fluctuation, or rapid heating or rapid cooling, when the maximum temperature is insufficiently high to promote a rapid increase in the amount of glassy matrix formed during the kiln firing of the bricks; and that higher temperature spalling effects should be treated rather as slag or fusion problems.

Five tons of a Scottish fireclay of specified chemical analysis, and of specified mechanical analysis in the dry ground state, were mixed with one ton of grog prepared from the same fireclay, the grog being ground and sieved. The mechanical analysis of the grog and that of the mixture are specified. The mixture was divided into three parts, the first part being prepared in an edge-runner mill for hand-moulding by the soft-plastic method. The batch contained 17.30 per cent. of water, and was formed into 412 bricks. The second part was mixed with water in a double-shafted paddle mixer, fed thence into a closed horizontal pug mill, and extruded as a clay column. This was wire-cut, and the clods pressed to form bricks. The water content of the clods as pressed was 11.26 per cent., and 300 bricks were made. The third part was fed into a mixer, treated with a fine spray of water, and fed at a water content of 4½ per cent. to the press boxes of a semi-dry machine. 324 bricks were made.

The bricks after drying were fired with thermoscope bars, 31 melted down, 32 bent, 33 only slightly bent. The porosity of all three sets of bricks was about 23 per cent. The cold-crushing strength of the semi-dry bricks was less than half that of the soft plastic bricks and the stiff plastic bricks respectively.

Specimens of each type were heated in seven hours to 1,050 deg. C., and kept at that for an hour, each being then placed upon a cold iron plate, and when cold the crushing strength of each specimen was determined.

A second set was subjected to five cycles of heating to 1,050 deg. C. and cooling on the iron plate before determining crushing strength, and a third set was subjected to ten cycles before crushing strength was determined.

The semi-dry brick was estimated to be most resistant to spalling conditions, stiff plastic brick next best, and soft plastic brick least resistant.

The soft plastic bricks in most cases showed reduced strength after being subjected to mild spalling conditions.

The stiff plastic bricks showed reduction in strength after one cycle, a further slight reduction after five cycles, and then an increase in strength after ten cycles.

The semi-dry bricks showed a large increase in strength after one cycle of heating and cooling; this maximum was somewhat diminished after five, and further after ten cycles, but the final strength was nearly 20 per cent. greater than the crushing strength of specimens of ash from the kiln. Great possibilities seem to exist for improvement of the resistance to spalling of fireclay bricks.

British Ironfounders' Association

ANNUAL DINNER IN LONDON

Merchant distributors of builders', ironmongers' and plumbers' materials were the guests of manufacturers at the annual dinner of the British Ironfounders' Association in conjunction with the British Bath Manufacturers' Association and the National Light Castings Ironfounders' Federation, held at the May Fair Hotel, Berkeley Square, London, W.1, on Wednesday of last week. That important third party, the consumer, was fittingly enough not forgotten, and in two of the excellent speeches made during the evening his interests were voiced in statements which laid emphasis on the necessity for manufacturers and merchants to introduce into their councils, and secure the co-operation of, consumers of their goods.

MR. W. R. BLAIR (chief executive officer of the British Ironfounders' Association) presided, and the company present numbered well over a hundred. At the high table, supporting the Chairman, were: Sir Alfred Hurst (independent chairman of the London Builders' Conference), Mr. J. B. Forbes Watson (director of the National Confederation of Employers' Organisations), Mr. H. Cheetham (President of the British Federation of Plumbers' Merchants' Associations), Sir W. R. Dudley Pryke (President of the Builders' and Plumbers' Merchants' Association), Mr. A. W. Steven (chairman of Allied Ironfounders, Limited), Capt. H. J. Kennard, R.N., Col. M. MacFarlane, Mr. Percy Donald, Mr. J. A. Glendinning, Mr. C. E. Bullock, Mr. A. E. L. Robey, Mr. W. Rennie, Mr. C. E. Clarke, Mr. V. Jobson, Mr. H. S. Brown, Mr. F. W. Cummings, Mr. John Turton and Mr. J. W. Rains.

The New System

The toast of the "light castings trinity"—the British Ironfounders' Association, the British Bath Manufacturers' Association, and the National Light Castings Ironfounders' Federation—was proposed by SIR ALFRED W. HURST. It was no mere gesture of courtesy, he said, that as representing the London builders—one of the largest buying organisations in the country—he should be a guest at the dinner of three associations which were among the most important suppliers of their materials. "It is because I believe there is a radical change in our whole national position in regard to industry," Sir Alfred declared, "and a complete change also in our outlook as to what is for the good of the country, that I propose this toast to-night."

He believed, Sir Alfred continued, that the economic system which they had built up through the centuries was now very much on its trial. Overseas, they saw the economic systems of one country after another toppling or becoming changed out of all recognition, and he was not sure that the capitalistic system as it had evolved in this country, with its characteristic individualism and freedom for every man to develop his own life and business with a minimum of interference from the State, could survive. Overseas, the liberty of the subject had been subordinated or completely submerged in the rights of the nation. Whether they looked at the Russian experiment or at Italy or Germany, the result was substantially the same; the individual counted for practically nothing, the State was everything.

Foreign Mistakes

"In looking upon the birth pangs of these new systems in a detached manner, feeling that they were not of great interest to us, we were guilty of a grave mistake. The problems which brought about these radical changes in Russia, Germany and Italy were present in this country to-day, and in some way or other they had to be faced. In the main the cause to which these changes were attributable was the failure of industrial leaders, great and small, to recognise their responsibilities to the nation. Industrial leaders in Germany, Italy and Russia had grown up as well as ourselves in an age when wealth came easily, when trade was expanding, and when the markets of the world were open to the enterprising."

Now, unfortunately, the time had been reached when that upward surge had ceased. The long and steady trend of expansion of trade in the last century had been dependent on the discovery and development of new markets and the rapid growth of population, but it was a trend which, with the deepest regret, he believed would not be seen in the future. To-day they were confronted with the problems of the depressed areas, of the mechanisation of industry depriving men of employment and even of the hope of ever securing re-employment; there was the upward rush of prices which preceded a boom and there was the prospect of cut-throat competition if a reaction set in.

Danger of Non-Co-operation

"Industry must take this matter in hand itself," Sir Alfred asserted, "or contemplate an increasing measure of Government interference. We industrialists have the responsibility and the opportunity at the present time of attempting to solve these problems ourselves, and the only way is by developing powerful trade associations such as you yourselves represent. The individualistic method of approach to a question of this kind is useless, but if trade associations are to be powerful and to exercise their influence with a proper sense of their responsibility to the nation, it is vital that they should be as far as possible comprehensive. The danger to all associations is the eligible people who remain outside."

He could respect the sturdy individualism of the man who strove to retain the unfettered conditions of trade enjoyed by past generations, but he could not respect his breadth of view. If a man did sincerely stand for an individualistic system, and earnestly desired to retain the right for people to determine their own fortunes in life, he should realise he would only destroy the things he cherished and wished to preserve if the integrity and power of associations which stood between reasonable industrial autonomy and extensive Government interference, were destroyed.

There was another type of person who stood aloof from trade associations for whom he had no respect. He referred to the man who paid lip service to all the ideals for which an association stood, who was quite willing to have prices maintained, to have standardisation of goods, and for the association to spend large sums of money on publicity and negotiate valuable agreements with competitors overseas to assist export trade, but who intended to stay outside and reap all the benefits available and give nothing in return.

Government Interference Rejected

The problem of how best to handle men of that type was one of the major questions confronting industry. It was so important to-day that such men should be brought into line with their fellows that some were asking for legal authority to compel them to join an association. Sir Alfred said he ventured to disagree as to the wisdom of that course. Parliamentary power brought with it responsibility to Parliament, which meant statutory rules and control, and he believed that they would find, if they tried to govern by parliamentary authority, that they would be making for themselves a procustean bed which dampened enthusiasm and crippled development.

Assistance from Buyer Groups

He maintained that the "light castings trinity" was an example of a desirable and effective alternative to the proposal to have recourse to Parliament. The problem of the man who stayed outside could, in his estimation, be solved if associations were prepared to co-operate and reach a concrete position. As representing the London builders, he believed he could powerfully assist them in maintaining their association by insisting that the members observed the rules laid down by the association, and they could powerfully assist his organisation in a similar way.

The CHAIRMAN, in his reply to the toast, referred first to the National Light Castings Ironfounders' Federation. The Federation was the organisation, he said, which concerned itself with the labour side of the industry. It was in a flourishing position to-day, and he was proud to be able to state that there had been no major disturbance in the industry since 1919, with the exception of the General Strike in 1926 in which all industry was involved.

Turning to the British Ironfounders' Association, he was happy to report that in the rain-water goods section of that organisation they occupied a strong and satisfactory position. By their arrangements with merchants' organisations they had been able to build up and maintain a state of stability, but there was one suggestion he would like to make, and that was that the organisation was a little "lop-sided," because in addition to rain-water goods, they controlled another department of production, namely stove, grate and range and fitted goods.

It was true that to some extent they had been successful in stabilising prices in the rain-water goods section, but they felt they had not been so successful as they might have been in the other had they enjoyed the co-operation of their merchant friends in an agreement covering the prices of those particular goods. He hoped that they would be able to approach the merchants soon and convince them that it would be in their interests to co-operate in the establishment of economic prices.

At the moment the British Bath Manufacturers' Association was passing through difficult times. They were attempting in the Association to operate a price maintenance agreement. Every effort was being made to achieve success, and he would point out that any failure which had been experienced was not due to lack of loyalty on the part of the merchants' organisations with whom they were collaborating.

Concluding, Mr. Blair said they should look in future to a development of the relationships which had previously existed in the form of co-operation. He thought it desirable, not to say essential, that as manufacturers and merchants they should bring into their councils so far as they could, and obtain the co-operation of, the users of their goods. Speaking unofficially, he wished to assure Sir Alfred Hurst that so far as they were concerned they would do all in their power to foster and encourage that co-operation which he had suggested was desirable for them. Finally he appealed to manufacturers to continue to co-operate among themselves. If that were done fully he was confident there would be no difficulty in securing co-operation among other sections of the building industry.

Inter-Federation Action Wanted

MR. A. W. STEVEN proposed the toast of the guests. There was, he said, a larger number of guests present that evening than ever before. In addition to representatives of all the merchant organisations with whom they had been working for many years, there were present members of a number of employers' associations en-

gaged in the supply of goods to the building trades, and these included the Brass and Copper Tube Association, British Sanitary Fireclay Association, Galvanised Tank Manufacturers' Association, National Association of Copper Cylinder and Tank Manufacturers, National Clay-Ware Association, National Pipe Federation, Sanitary Earthenware Manufacturers' Association, and the United Kingdom Lead Manufacturers' Association.

"I have been connected with the ironfounding industry for fifty years," said Mr. Steven, "and in that comparatively short time I have observed interesting developments. In my youth the law of the industry was the law of the jungle, and that state of affairs is neither good for the employer nor his employees. Prosperity in our industry is a necessity if we are going to give a decent livelihood to our workers, and that is one of our responsibilities to-day. I firmly believe the continuation of our present *régime* is dependent to a large extent on how we discharge this duty.

"One of our problems at the moment is the free-lance merchant. Is it not possible to combine with other manufacturers' associations in the building industry and to bring it as a whole into some state of ordered control? I believe it is possible, if we take advantage of the present opportunity, to supply the building industry with greater efficiency than ever before, and with goods of an ever-improving quality at reasonable prices, to the benefit of all concerned —manufacturer, merchant and consumer."

International Forty-Hour Week

MR. J. B. FORBES-WATSON, who replied to the toast, recalled that sixteen years ago he had been connected with the National Light Castings Ironfounders' Federation. He was now, he said, director of an organisation representing industries in this country employing over eight million workers. A year ago he had spent some months at Geneva endeavouring to persuade delegates from other countries that international agreement on the introduction of a 40-hr. week in industry was impossible. Germany, which would be outside the scope of any such arrangement, was, on its own showing, working more than 48 hrs. per week, in 30 per cent. of its industries, and Italy, which sponsored the idea, had on the introduction of a 40-hr. week for her workers, reduced their wages. For the last four years he had successfully opposed the proposal, but next year it would again be introduced and discussed, with what result he could not predict.

The Bath Situation

MR. H. CHEETHAM, speaking as a merchant, also replied. He described the B.I.A. price maintenance agreement as "entirely satisfactory." As an agreement between manufacturers and distributors, it was a model for the stabilisation of conditions in other sections of the industry. It was time, he added, that more of the spirit of trade agreements was evidenced, and less of the hair-splitting disputes experienced over the meaning and interpretation of such and such a clause. Sooner or later he felt there would be a triple alliance of producer, distributor and consumer, working on sound and sensible lines, exerting the best possible influence in trade and industry.

Mr. Cheetham went on to refer to the British Bath Manufacturers' Association. It would be idle, he said, to gloss over the difficulties that faced them in that organisation. For three years the best efforts of the best interests in the manufacturing side of the bath industry and of the best interests in the merchanting side had been put in to the Association—three years of hope and of sacrifice—and to-day they were faced with the most serious crisis that had yet confronted them.

As President of the British Federation of Plumbers' Merchants' Associations, it was a pleasure for him to announce that, from a general meeting, their Executive had received the strongest possible instructions to do everything they could to achieve stability in the bath section of the trade. They fully realised that if they failed to achieve that desired stability, it would have a bad effect on other sections of the industry. It would not be an easy task, but if they remembered they had devoted three years of effort to the agreement, and that in spite of tremendous difficulties which had had to be faced, the B.I.A. had hung together, they would not let the arrangement lapse. They could not afford to let the agreement go into the wilderness and have a free price period, because free prices had nothing to teach them that was good.

This task must be faced, said Mr. Cheetham, with some of the courage that was shown by the original negotiators of the B.I.A. agreement. He hoped they would produce something which would be acceptable to all sections of the trade, and, having produced it, that they would devise means of ensuring that it would be honoured.

In his concluding remarks Mr. Cheetham mentioned the Distributors of Builders' Supplies Joint Committee. Its origin, he said, could be traced to a recognition by merchants of the fact that it was quite impossible to discuss their mutual problems piecemeal, but that they must discuss them in relation to each other, that they must have some means of expressing the views they held as a whole through a central co-ordinating medium.

Some manufacturers appeared to subscribe to the view that the D.B.S.J.C. was an attempt to stampede merchants' organisations into rash action. He wished to disabuse them of that opinion. It was impossible for the Committee to make a single recommendation unless it had the unanimous approval of all the members. There was emphatically no conception of ruling the trade by a little body which met once every four months in London.

Those who were represented on the D.B.S.J.C. believed distribution could be a dignified business for all concerned, and not a mad scramble. They believed it could be a dignified occupation for all engaged in it, whether big or small, provided they had some experience and service to offer and some financial stability. They believed they would receive the co-operation of the manufacturers jointly, when they placed their plans before them, and when they attained that goal they would have the satisfaction of knowing they had contributed something towards organised production as well as organised distribution.

MR. HOLLOWAY proposed the toast of the chairman, to which MR. BLAIR replied in his usual graceful manner.

During the evening the company was entertained with songs by Mr. Andrew Shanks, who is a director of Shanks & Company, Limited, of Barrhead, and a member of the B.I.A.

BRITISH IRONFOUNDERS' ASSOCIATION ANNUAL DINNER AT THE MAY FAIR HOTEL, MR. W. R. BLAIR PRESIDING.

THE COUNCIL of the Irish Free State Industrial Development Association, at its last meeting, considered a letter from the Irish Engineering and Foundry Union and from the Hammond Lane Foundry Company, Dublin, protesting against the continued importation of castings, especially seat standards for cinemas, which has created unemployment in an industry subject to high tariffs. It is proposed to approach the Irish Free State Government and insist that these standards be produced in the Free State and a quota imposed if necessary.

The Production of Dense Iron Castings*

By J. H. WILLIAMS, B.Sc., F.I.C.

Much has been written in recent years on the production of dense cast iron and some apology is perhaps needed for adding to the volume of literature on the subject. It is proposed to consider here some metallurgical principles which govern the manufacture of dense cast iron and their application to foundry practice, as it is thought that a study of these principles will lead to a clearer conception of their influence in affecting the denseness and structure of cast iron.

With respect to the term "dense iron," the use of such words as high-tensile or high-duty cast iron has been avoided, because it is not the author's intention to restrict the subject only to those castings which must possess high mechanical strength combined with high resistance to porosity, but to embrace a wider range which includes castings of a more moderate standard. Many foundrymen are often asked to make a good, dense casting which must be free from unsoundness, without anything being specified regarding the mechanical properties of the iron comprising the casting; the only condition, if any, laid down is that the casting must be easily machined. Of course, in many cases, the casting supplied has a high mechanical strength because the density required necessitates making the casting with iron possessing at least a fairly high-tensile strength, but it is necessary to point out that strength *per se* is not the primary object with which the foundryman is concerned.

What are the attributes of a dense cast iron of good quality? To possess a dense or close-grained structure, the graphite flakes must be small, nests of eutectic graphite should be absent, the ground-mass must be free from small cavities, carbide segregates, porous patches and gross slag inclusions, and as free as possible from the ever-present minute gas-holes. Obviously the problem is somewhat complicated.

Chemical Composition

It is clear that, irrespective of other precautions, to obtain sound castings one must have good, clean or well-scavenged iron of suitable chemical composition in the ladle. A slight digression at this point on the question of chemical composition is perhaps advisable. In former days, castings were made by selecting pig-irons the suitability of which was judged by the appearance of the fractures. With the introduction of scientific methods into foundry practice, the appearance of the fractures became of secondary importance and chemical analysis was soon regarded as a better means of selecting pig-iron and controlling furnace charges. There is no doubt that the method of chemical control, by its greater exactness, effected a decided improvement in the quality of iron castings, but the almost complete neglect of structure as visualised in the fractures of the pig-iron was to be deplored. Demands for castings, however, of greater strength became insistent, and as these could only be met by making the iron denser, the physical structure as well as the chemical composition of cast iron inevitably came under investigation. To-day it is well known that iron cast in the same sectional thickness and having the same chemical composition may vary greatly in mechanical strength.

The Graphite Structure

The weakness of cast iron is largely due, though by no means entirely so, to the presence of graphite flakes distributed throughout its mass, which break up the continuity of the metal and lower its strength. According to whether the rate of cooling is fast or slow, so will the graphite flakes be smaller or greater in size. Also, the greater the quantity of graphite and the coarser the flakes, the lower will be the mechanical strength of cast iron because large graphite flakes have appreciable dimensions and the continuity of the metal is broken to a greater extent, leaving only a few metallic bridges. It can be readily appreciated, therefore that for a given chemical composition a cast iron may have either a coarse crystalline structure with large but not very many graphite flakes, or a uniform fine-grained structure in which the graphite exists in numerous small and well-distributed flakes. In the second case, the mechanical properties of the iron as represented by the transverse and tensile strengths will be greatly superior to those of the first, and often the difference between the tensile strengths of two irons of similar composition will be as much as 50 per cent.

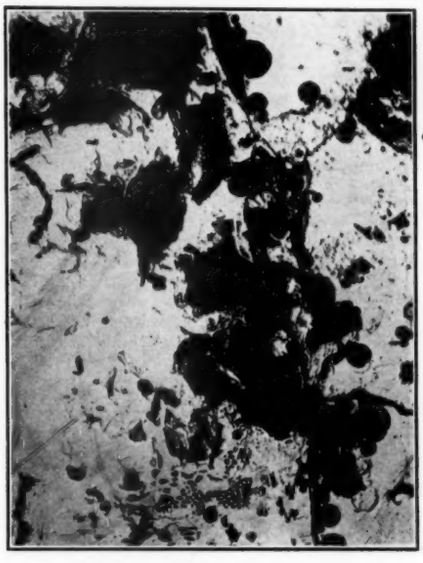


FIG. 1.—PIG-IRON RICH IN OXIDES. × 300.

Silicon Briquette Additions

To ensure the production of fairly close-grained cast iron from mixtures of pig-iron and remelts, it is necessary to use only fairly close-grained pig-iron in the furnace charges. Coarse-grained pig-iron with an open fracture should be sedulously avoided, as the graphite flakes are correspondingly larger. In the closer-grained foundry pig-irons the graphite is much smaller; but such pig-irons usually have only a medium silicon content of 1.5 to 2.5 per cent., so that when incorporated in a charge, the silicon content of the resultant cast iron is too low for most purposes. To overcome this difficulty, extra silicon is added to the charge in the form of silicon briquettes, which contain graded particles of 45 to 50 per cent. ferro-silicon. This is a kind of inoculation process and the graphite liberated by the softening action of the silicon separates out in the form of small, fine flakes.

This method of procedure, whereby only close-grained, if somewhat hard, pig-irons of medium silicon content are employed, and further softening, if required, is carried out by the addition of briquetted ferro-silicon to the charges, is the outcome of the "nuclei" or "germ" theory proposed some ten years ago by Piwowarsky, who showed that a fine-grained graphitic iron could be produced by superheating coarse-grained pig-iron to a temperature of 1,500 deg. C. By analogy, therefore, the use of fairly close-grained pig-iron with a medium silicon content in cupola melting would lead to a greater dissolution of the graphite and a lesser amount of graphite residues being left to act as nuclei for graphitic crystallisation in the cooling iron. The mixtures of harder but closer-grained pig-iron and remelts are then softened to the desired extent by the addition of silicon briquettes to the charge.

Newer Theories

It is now known that the "nuclei" theory of explaining the formation of coarse graphite flakes in iron castings is not entirely correct, and Piwowarsky himself, in a Paper published early this year, has shown that the graphitic structure in cast iron is greatly influenced by crystallites of silica and slag inclusions. Dr. Norbury, also, in a Paper presented to the Annual Conference of the Institute of British Foundrymen in Glasgow this year, has shown that the presence of titanium, most probably in the form of titaniferous slags, has a great influence on the size of the graphite flakes. Whatever the explanation may be, however, the fact remains that the use of coarse-grained pig-iron materially conduces to the formation of a coarse-grained structure in castings made from pig and scrap iron charges.

The use of refined pig-irons in which the graphite exists in fine flakes is a tacit acknowledgment of the advantages pertaining to close-grained irons. Modern hot-blast foundry pig-irons with a coarse, open fracture and a silicon content of 3 per cent. and upwards are apt to contain appreciable quantities of highly dispersed oxides and crystallites, which do not appear to be removed in the melting process and pass largely into the cast iron. Fig. 1 is a particularly bad example of a pig-iron (silicon 3.55 per cent.) containing an excessive amount of oxide and slag inclusions which would almost certainly give rise to trouble in the foundry.

In the writer's opinion, many of the differences in pig-irons which pass under the vague terms of "body," "inherent properties," etc., are due to the presence of these highly dispersed oxides and crystallites, which are not revealed in the ordinary routine analysis of pig-iron. The presence of included oxides in iron often gives rise to puzzling results, as the following example shows. A pig-iron containing 3.2 per cent. of silicon, supplied by "A," was used for the manufacture of certain castings. Subsequently, a pig-iron with the same silicon content, but supplied by "B" was used. As the silicon contents were identical, one would assume that the castings would not be affected by the substitution of one iron for the other, but the castings suddenly became harder and a more precise examination showed that the silicon in the iron from "B" was partly present in the form of silica, which thus took no part in the softening reaction.

High Oxide Content Pig-Irons

Along with the high-silicon pig-irons, the very low silicon or white irons likewise possess a high oxygen content which gives rise to a heavier loss of manganese and silicon on melting than one experiences with grey irons. All are aware that the addition of white iron to a charge may cause trouble unless suitable precautions are taken to eliminate the oxides. Any faults are usually attributed to sulphur irrespective of the fact that the resultant iron may not possess an unduly high sulphur content.

Retention of Non-Metallic Inclusions

In view of Piwowarsky's work on the influence of silica crystallites and oxide inclusions in promoting the formation of coarse graphite, it is probable that they are the chief cause of coarse graphitic crystallisation in cast iron, and the presence of unmelted residues of graphite is only of secondary importance. The question may be asked: Why are these small oxide inclusions not removed when the iron is melted, particularly as

* Paper read before the London Branch of the Institute of British Foundrymen, Mr. V. Delport presiding.

their density is considerably less than that of the molten iron? The answer is that they are very small and pass enclosed in the molten iron through the slag layer almost unaffected. Once in the ladle, they may be regarded for all practical purposes as stationary. The presence of oxides may always be suspected when an iron tends to "go off" or becomes sluggish more rapidly than one would normally expect.

Eutectic Graphite

A common defect, although not often recognised as such, is the presence of numerous isolated nests of eutectic graphite in castings. In many common castings, its presence is of no great moment, but in dense castings it is better avoided. Areas of eutectic graphite (Fig. 2) are characterised by the occurrence of numerous minute flakes of graphite in close proximity one with another and by the smaller size of the flakes compared with the normal graphite in the iron. The presence of these areas of eutectic graphite means there are innumerable minute patches of a soft nature.

Eutectic graphite can separate from both hypo-eutectic and hyper-eutectic iron-carbon alloys when crystallisation takes place with marked undercooling, but in the writer's experience it is more liable to occur during the solidification of hyper-eutectic alloys, *i.e.*, those grey irons in which the total carbon is greater than that required by the chemical composition of the iron to form the iron-carbon eutectic. Pure iron combines with 4.3 per cent. of carbon to form the lowest melting alloy of iron and carbon, which is known as the iron-carbon eutectic. The addition of silicon, phosphorus and nickel lowers the quantity of carbon which can be dissolved by the iron and the presence of manganese and chromium increases it. Hence, for any specified chemical composition there is a corresponding eutectic point which it is possible to calculate from the chemical analysis of an iron.

Pinholing

Another defect occasionally met with in castings is an excessive number of minute gas-holes, usually referred to as pinholes. Molten iron has the property of absorbing more gas than it is able to hold in the solid state and on cooling the dissolved gases are evolved. Again, carbon reacts with the oxide inclusions in molten iron to form carbon monoxide. If iron is poured at too low a temperature, then the metal is apt to contain an enormous number of pinholes of all sizes up to 0·1 mm. in diameter.

Elementary Defects

With this knowledge of some of the factors which must be taken into consideration in casting dense iron, the next procedure is to see how they can be applied to the production of dense iron. Firstly, it will be best to consider castings made from mixtures of ordinary foundry pig and scrap iron. These will include all castings which are not of the highest class, but are fairly dense and suitable for many purposes. From what has been stated above, it is advisable to use foundry pig-irons with a reasonably close grain in order that the graphite flakes in the cast iron shall be as small as possible. Most of the modern cheap phosphoric pig-irons, with silicon up to 3 per cent., possess a fairly close fracture, and, where a phosphorus content of about 1 per cent. is permissible in the castings, they are satisfactory from the point of view of graphite size. On the other hand, the high-phosphorus content lowers the eutectic point and therefore the total carbon must be sufficiently low to avoid the separation of eutectic graphite. This difficulty can usually be surmounted by incorporating a large proportion of scrap iron in the charge.

FIG. 2.—SHOWING NESTS OF EUTECTIC GRAPHITE. × 100.

FIG. 3.—T.C 3.39; Si 1.89 AND Mn 1.03 PER CENT. × 100.

FIG. 4.—T.C 3.33; Si 1.70 AND Mn 0.77 PER CENT. × 100.

High Scrap Charges

The writer has obtained very good results with a charge consisting of 80 to 85 per cent. of scrap iron and remelts and 20 to 15 per cent. of phosphoric pig-iron (silicon about 2.5 per cent.). For such mixtures old railway chairs have been found to be very suitable because their composition seems to be fairly regular in the sense that the silicon may vary from 1.8 to 2.5 per cent., sulphur is not as a rule over 0.08 per cent., manganese may vary widely, but is usually rather low, which is not a matter of much importance, and phosphorus is fairly constant around 1 to 1.3 per cent. Railway chairs, unfortunately, are nearly always rusty and very dirty, so that some care is called for in their use. Machinery scrap may be of far better quality, but the composition may vary enormously, and it is very difficult, if not impossible, to assess a heterogeneous mass of scrap.

Compositional Readjustment

The use of a heavy percentage of remelted metal in the charge considerably assists in producing a moderately fine graphitic structure and rendering the iron hypo-eutectic. Such a charge will necessarily need some "doctoring." It will probably require softening down with a silicon addition, and it will certainly require a manganese addition to bring up the manganese content to about 0.6 per cent. and act as a de-oxidising agent. Ferro-manganese or spiegeleisen may be used for this purpose, but manganese briquettes, which contain manganese in the carbonless form or with a low carbon content only, are far superior for de-oxidation. When spiegeleisen or ordinary ferro-manganese, which as blast-furnace products contain the manganese in the form of carbides, is used, there is the possibility of the manganese being taken up by the iron with very little scavenging or reduction of oxides, because the carbides of iron and manganese must be broken down before the manganese is free to effect any reduction, and this dissociation takes place slowly and only at high temperatures. Consequently, although raw materials containing manganese carbides are efficient in air-furnace or electric-furnace melting, they are by no means always so effective in cupola melting.

In the first case, the metal can be "stewed" in the furnace until complete dissociation has taken place, while in the cupola the time during which the metal remains molten is limited. It is highly probable that many of the discordant results obtained by manganese additions may be attributed to this fact. Figs. 3 and 4 are photomicrographs taken from exactly similar castings made from charges containing spiegeleisen and carbonless manganese briquettes respectively. Fig. 3 shows the coarse graphitic structure in a casting made from a charge of 10 cwts. containing 1 cwt. of spiegeleisen, equivalent to 13 lbs. of manganese. The cast iron contained 1.03 per cent. of manganese, and had a tensile strength of 12.9 tons per square inch. Fig. 4 shows the graphitic structure in a casting made from a 10-cwt. charge containing six manganese briquettes, equivalent to 6 lbs. of carbonless manganese. The manganese content of the iron was 0.77 per cent. and the tensile strength 15.9 tons per square inch.

Aluminium as De-oxidiser

Ferro-aluminium is also useful as a de-oxidiser, about 1¼ lbs. being added to each ladle of metal from a 10-cwt. charge. The alloy should be broken up into small pieces, placed in a paper bag and thrown into the ladle while the iron is being tapped from the furnace. The difference between using and not using a de-oxidiser is often very apparent, the fluidity of the metal being increased and its "life" lengthened.

The process of using such heavy proportions of scrap iron in the charge, yielding a moderately

fine graphitic cast iron with a high phosphorus content, is limited as a rule to castings of moderate strength, such as many machinery castings, or those of nearly uniform thickness. It cannot be employed in the continuous production of light castings owing to the rapid increase in the sulphur content of the metal *via* the foundry returns, which bulk large in relation to the weight of the castings. The high phosphorus content extends the freezing range owing to the presence of a comparatively large amount of fusible phosphide eutectic.

In grey cast iron the phosphide eutectic does not consist of iron phosphide, Fe_3P, only, but a mixture of iron phosphide and iron containing in solution a little phosphorus. The total phosphorus content of the eutectic is about 10 per cent. Hence, phosphorus gives rise to the formation of approximately 10 times its own weight of eutectic which solidifies at the comparatively low temperature of 943 deg. C. Castings made with high phosphoric iron can, therefore, be fed with the aid of a thin iron rod, but, in spite of this, cavities and porous patches are apt to be formed internally, particularly near bosses and wherever sections meet or thicken. Although such castings may, and frequently do, possess a reasonably good tensile strength, they have a poor transverse strength and deflection owing to the quantity of brittle phosphide eutectic present.

Phosphorus Control

Where maximum denseness combined with freedom from porosity and other defects is required in sections of varying thickness, it is usually necessary to reduce the phosphorus content of the iron, while retaining a fine and uniform graphitic structure. The iron should also possess a moderately high manganese content of 0.8 to 1.0 per cent., which ensures reasonably well that any iron sulphide present will be converted into the innocuous manganese sulphide. Further, for high-duty irons, the matrix should be pearlitic or as nearly pearlitic as possible.

Much work has been done in recent years by West and others on the influence of phosphorus on the denseness and porosity of cast iron. Every casting must be treated individually. It must not be forgotten that the phosphide eutectic, being a hard if somewhat brittle constituent, often confers greatly increased wearing properties, and a certain amount is often advantageous. A few timely remarks on this matter appeared in an article by Smith in the FOUNDRY TRADE JOURNAL, April 9, 1936. Where a casting does not vary considerably in sectional thickness, there is not much difficulty as a rule in making it sound in an iron having a medium phosphorus content, but in other cases it is advisable to reduce the phosphorus to 0.3 per cent. or even lower. A point of importance is that soundness and strength are of a higher standard in an iron containing, say, 0.6 per cent. phosphorus, when the eutectic is distributed throughout the mass in small aggregates than when it is present in the form of less numerous but much larger segregates.

The conditions enumerated above for producing dense castings are readily obtained by melting down, taking appropriate precautions, mixtures of steel scrap and low phosphorus or medium phosphorus pig-irons.

Steel Scrap Additions

As before, it is advisable to use pig-iron with not too coarse a crystalline fracture, though in the presence of steel scrap, which has a higher melting point than pig-iron, there does not seem to be so much danger of large graphite flakes separating out in the resulting cast iron. Probably the higher melting point of the mixture accounts for a more rapid solution of the graphite and the almost invariable addition of manganese leads to a greater reduction of the oxides and crystallites which promote coarse graphite crystallisation.

The steel scrap should, for preference, contain a certain proportion of T, L or H shaped sections instead of being composed entirely of flat pieces. Pieces of constructional steelwork give excellent results. However, one may obtain equally good results, for example, with fishplates, but if these lie flat on the coke layer they tend to impede the equalised distribution of the gases up the cupola. Steel is readily oxidised in the upper oxidising zone of the cupola, and therefore the steel scrap employed must not be too thin; sections of $\frac{1}{4}$ to $\frac{1}{2}$ in. thickness are satisfactory. The addition of steel scrap to the charge materially reduces the total carbon, and this is the main reason for its use. Incidentally, it lowers the phosphorus content somewhat.

In formulating a mixture for a high-tensile iron casting, it is first necessary to decide what must be the chemical composition of the iron so that the metal will consist of small graphite flakes, together with the inevitable aggregates of phosphide eutectic and manganese sulphide, embedded in a pearlitic matrix.

Pearlitic Iron

It is well known that the structure of iron in a casting varies with the difference in sectional thickness, and that an iron whose composition will yield a pearlitic structure in a section of a certain thickness will give a softer iron in a thicker section and a harder iron in a thinner section. Consequently, it is impossible to formulate the chemical composition of an iron for any cold-mould process which will give a pearlitic structure solely in all parts of a casting where there is much variation in sectional thickness. A compromise has to be adopted whereby important parts are made pearlitic or as nearly pearlitic as possible.

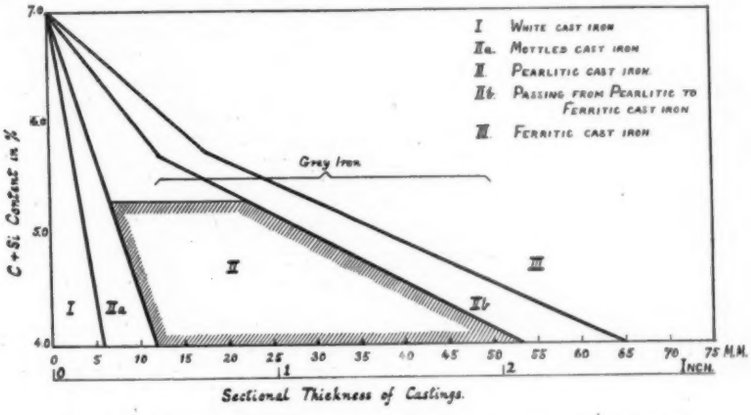


FIG. 5.—PHYSICAL STRUCTURE OF CAST IRON RELATED TO COMPOSITION AND SECTIONAL THICKNESS, DUE TO GREINER AND KLINGENSTEIN.

Determining Factors

The structure of the metal in an iron casting is governed by three factors, *viz.*, the chemical composition, the thickness and the rate of cooling. Assuming normal cooling, carbon and silicon are the main elements which influence the physical constitution of cast iron of a given sectional thickness. Phosphorus has no marked influence on the condition in which carbon occurs in cast iron, and manganese, in the quantities usually present in ordinary grey iron, has also but little effect. In Fig. 5 is reproduced the diagram of Greiner and Klingenstein for cast iron, to which the writer has already drawn the attention of foundrymen in a previous publication. In this diagram is shown the relationship existing between the sectional thickness, the composition expressed as the *sum* of the percentages of carbon and silicon, and the physical structure of cast iron.

It must be carefully noted that the ordinates are obtained by adding together the percentages of total carbon and silicon. Then for a definite combined-carbon and silicon percentage, the diagram shows in which zone (white, mottled, pearlitic, partly pearlitic and partly ferritic, or ferritic only) the iron will solidify for any given thickness. The shaded area on the diagram indicates the useful part of the pearlitic zone for making pearlitic iron castings. Used with a certain amount of discretion, the writer has found this diagram very useful.

An example will illustrate how the diagram is to be used. Presuming a section is $\frac{3}{4}$ in. thick, reference to the diagram will show that in the shaded pearlitic zone, the combined figures for carbon and silicon lie between 4.0 and 5.3 per cent. An average figure will be about 4.7 per cent. Hence, an iron with 3.2 per cent. total carbon and 1.5 per cent. silicon will satisfy the conditions for a pearlitic matrix. If the possibility of a little free ferrite being present is of no importance, then a higher limit may be taken, say 5.0 per cent., which will allow the iron to contain 3.3 per cent. total carbon and 1.6 per cent. silicon.

Influence of Cupola Practice

The total carbon obtained by melting down various mixtures of pig-iron and steel scrap varies with different cupolas and with the quality of the coke. Reliable figures for any individual cupola can only be ascertained by direct experiment. Most cupolas, however, will yield an iron with a total carbon content of about 3.2 per cent. when a charge containing 30 per cent. of steel scrap is melted down. Progressive increments of steel scrap do not necessarily increase the denseness of cast iron; 20 to 25 per cent. of steel in a charge will probably be sufficient to confer maximum denseness though it may not be enough to yield a completely pearlitic groundmass. Steel scrap additions up to 30 per cent., or even 40 per cent., to a charge, say for casting a 1.6 per cent. silicon iron, will result in a progressive increase in mechanical strength, but the writer has repeatedly noticed that further additions will show a marked falling-off in the strength of the resulting cast iron until the amount of steel scrap added exceeds 75 per cent., when there is a rapid rise in the tensile strength. Fortunately, it is not often one requires to add more than 30 per cent. of steel, but, if so, then the writer finds it is often better to add 75 per cent. and adjust accordingly. On the Continent, where receivers are commonly attached to the cupola, this difficulty does not appear to arise.

Manganese as a Scavenger

The quantity of steel scrap to be added to a charge will therefore be governed by the total carbon and perhaps the silicon required in the cast iron. When the charge has been roughly calculated, allowance must be made for oxidation losses on melting. Even with careful blowing, a charge containing 30 per cent. of steel will lose about 15 per cent. of its silicon and anything between 25 to 40 per cent. of its man-

ganese. Neglecting the manganese in the steel scrap and assuming a loss of 20 per cent. manganese from the pig-iron and remelts will usually give a very close approximation to the manganese figure found by analysis in the cast iron. Manganese must always be added to the charge in some form, either as ferro-manganese, spiegeleisen, high-manganese pig-iron or manganese briquettes, to de-oxidise the molten iron and raise the manganese content to about 0.9 per cent.

When steel is melted in a cupola it becomes superficially oxidised before reaching the melting zone and manganese is necessary for de-oxidation. Additional manganese is also required to counteract the melting loss and convert any iron sulphide into manganese sulphide. When low carbon manganese briquettes are used, about 0.3 per cent. manganese is nearly always sufficient for de-oxidation. Any silicon addition needed is best made with silicon briquettes, which are added along with the manganese briquettes on top of the steel scrap in the furnace and covered with the pig-iron and remelts.

Slag Composition

Very little attention as a rule is given to the composition of slags in cupola melting, but the subject is not unimportant and is worthy of a few remarks, particularly when mixtures containing steel are melted down. As stated above, steel becomes superficially oxidised in the cupola before reaching the melting zone Assuming that the oxide or scale formed is ferrous oxide, FeO, then the following slag reactions can occur:

$$xFeO + \begin{cases} Si = 2Fe + SiO_2 \text{ (acid)} \\ Mn = Fe + MnO \text{ (basic)} \\ C = Fe + CO \text{ (gaseous)} \end{cases}$$

$$SiO_2 + MnO = MnO.SiO_2 \quad \text{M.P. 1,285 deg. C.}$$

$$SiO_2 + 2MnO = 2MnO.SiO_2 \quad \text{M.P. 1,365 deg. C.}$$

The reaction between manganese and iron oxide is much greater than between silicon and iron oxide. Hence, the heavier melting loss of manganese as compared with that of the silicon. This, of course, is equivalent to saying that manganese is a more energetic de-oxidising agent than silicon. The slow dissociation of the iron-manganese carbides which occurs during melting liberates carbon in a nascent state which most probably reacts vigorously upon oxides forming carbon monoxide in the molten metal. Oxidation of manganese, although often regarded as a dead loss, performs a certain amount of useful service by lowering the viscosity of the slag. Manganese metasilicate melts at 1,285 deg. C. and the orthosilicate at 1,365 deg. C. and the presence of manganese in complex lime-iron-manganese silicates forms thin fluid slags which have decided advantages upon which it is scarcely necessary to labour.

Slag and Sulphur-Manganese Balance

Very closely connected with the subject of slag is the so-called manganese-sulphur balance, which states that the amount of manganese needed to neutralise the sulphur is 1.7 times the percentage of sulphur plus an excess of 0.3 per cent. In this proportion, sulphur is presumed to be present entirely as manganese sulphide, and the iron to be at its softest with respect to these two elements. While this rule is no doubt generally true, not infrequently something appears to go wrong and leads to the separation of the iron-iron sulphide eutectic in the presence of a large excess of manganese. Attention has been drawn to this phenomenon from time to time. In 1934, McNair, in a Paper read before the Scottish Branch of the Institute of British Foundrymen, gave an extreme case in which 0.07 per cent. of sulphur in the presence of 0.82 per cent. of manganese, which is almost twelve times the quantity of sulphur, resulted in the separation and segregation of the iron sulphide eutectic. He appears to regard the matter as common knowledge, and mentions that the eutectic, owing to its low melting point of 980 deg. C., often takes the form of small pellet-like extrusions on a flat surface, which are extremely difficult to remove in the fettling shop. On examination these pellets were found to contain 30 per cent. of sulphur and the remainder iron. McNair then goes on to say: "Yet in nearly every case which has been noticed the manganese was in excess of that required for stabilisation of the sulphur."

The writer has never noticed such a segregation of iron sulphide eutectic in melting with an air or an electric furnace, but he has observed it on rare occasions in cupola work, and, in his opinion, when iron sulphide eutectic separates out in the presence of an excess of manganese, it can be taken for granted that there has been insufficient time for the manganese carbides to become dissociated in the melting process and so allow the free manganese to react with the iron sulphide. It is most likely to occur when melting is very hot and fast. Under these conditions, a briquetted manganese alloy with a low carbon content is far more reactive than any material in which the manganese exists in the combined form of carbides.

Blast Conditions

If but little notice is taken of the slag, some attention as a rule is paid to the blast, though often it is left to the judgment of the furnaceman, which is not to be despised in the case of a good man. Steel mixes, however, require very careful attention if the best results are to be obtained from a cupola furnace. Sometimes a simple pressure gauge is fitted or even a simple Pitot tube is fixed to the blast main, but it is well worth while to use an N.P.L. pattern Pitot tube as it is more reliable. The writer employs a Pitot tube, very similar to the N.P.L. design, connected to a blast meter which is calibrated to read directly the velocity of the air current. The complete outfit is made by J. C. Eckhardt A.-G., of Stuttgart, and is fitted into a portable wooden case. Smithson (FOUNDRY TRADE JOURNAL, November 28, 1935) has described a simple cupola blast volume gauge, using the N.P.L. pattern Pitot tube connected to a differential pressure gauge which any chemist can readily fit up from ordinary laboratory apparatus.

It is admitted that no instrument for measuring the pressure or volume of the blast will obviate the need for keeping a close control on the cupola itself, but it is of the utmost importance to control the blast as far as one can in order to obtain the best results from steel mixes. Careful blowing is very necessary when steel scrap forms the major part of the charge. One of the commonest causes of failure to obtain excellent dense castings is due to overblowing. Oxides of iron, manganese and silicon are present at the beginning in the cold charge. During melting they increase to a very appreciable amount. These oxides are partly absorbed by the slag but a part passes into the iron, where they influence the growth of the graphite and react with carbon to form carbon monoxide, which if the iron is sufficiently liquid, escapes, but is otherwise retained.

Although the preparation of clean iron of suitable composition greatly conduces towards the production of a dense sound casting, it is to be regretted that in many cases, especially where there are bosses and corners and variations in sectional thickness, it is impossible, by metallurgical control only, to secure equal denseness and freedom from porous patches in all parts without recourse to internal or external denseners. Good metal, of a composition appropriate for the job, will often allow a casting to be made free from chills or denseners or, at the worst, will reduce their number to a minimum.

(Concluded from next column.)

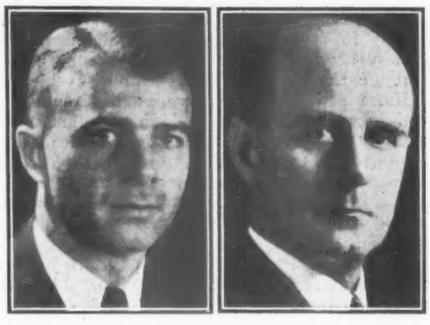
heat-treating furnaces, uses of steels, tungsten-carbide cutting tools, heat-treatment with liquid baths, and metallurgical inspection of gear steels. He is a member of the American Society for Metals, American Society for Testing Materials, and the Institute of Metals.

American Foundrymen's Association

EXCHANGE PAPER AUTHORS

Mr. O. W. Ellis, who is to present the American Foundrymen's Association Exchange Paper before the 1937 meeting of the Institute of British Foundrymen, is director of metallurgical research at the Ontario Research Foundation, Toronto. Mr. Ellis is noted for his research on high-strength brasses, bearing metals, heat-treatment of steel, and forgeability of metals.

He was born in England, at Swindon, and received his technical training at the University of Birmingham, graduating with the B.Sc. degree in 1914 and the M.Sc. degree in 1917. From 1905 to 1910, Mr. Ellis served as apprentice for the Great Western Railway at Swindon, and in 1910 and 1911 he was assistant to the apprentice supervisors of the Canadian Pacific Railway, Montreal. From 1914 to 1921 he was metallurgist at the Royal Ordnance Factories, Woolwich, and in 1921 he returned to Canada to accept a position as assistant professor of metallurgical engineering at the University of Toronto, remaining there until 1925. At this time he was appointed Industrial Fellow at the Mellon Institute, Pittsburgh, Pa. From 1926



MR. W. PAUL EDDY, JUN. MR. O. W. ELLIS.

to 1929, Mr. Ellis held a position as research metallurgist with the Westinghouse Electric & Manufacturing Company, at East Pittsburgh. In 1929 he returned to Canada to accept his present position.

Mr. Ellis is a member of the American Foundrymen's Association, Institute of Metals, Iron and Steel Institute, American Society of Mechanical Engineers, American Society for Metals, American Society for Testing Materials, Society of Automotive Engineers, and the American Institute of Mining and Metallurgical Engineers.

Mr. W. Paul Eddy, jun., who is to present the American Foundrymen's Association Exchange Paper for the 1937 meeting of the French Foundry Technical Association, is chief metallurgist of General Motors Truck Corporation, Pontiac, Mich. Mr. Eddy was born in 1899, in Syracuse, N.Y., and received his B.S. in chemical engineering from Syracuse University in 1922. For two years after graduation he was chemist at the Crucible Steel Company of America, in Syracuse. In 1924 he went to the Geometric Tool Company as assistant metallurgist, and was made chief metallurgist in 1925. In 1928 Mr. Eddy returned to Syracuse as assistant metallurgist of the Brown-Lipe-Chapin Division, General Motors Corporation, and in 1930 became chief metallurgist of General Motors Truck Corporation.

Mr. Eddy has written many Papers, and has covered such subjects as effect of various elements in steel, heat-treatment of non-deforming steels, induction heating, construction of

(Concluded in previous column.)

Sand Preparing Plant at Cathcart Foundry

G. & J. WEIR'S NEW INSTALLATION

As a result of an article which we published in our issue of July 30, there has been a number of requests for further details of the sand preparing plant installed by G. & J. Weir, Limited, of Cathcart, and we are indebted to Mr. G. E. France, managing director of August's, Limited, for the following details.

The plant illustrated in Fig. 1 consists of two main and separate sections: a used foundry sand cleaning plant, and a sand mixing and aerating section. The cleaning section or the mixing section may be worked independently, or both can be worked simultaneously. This plant is solely devoted to dry sand, and is capable of dealing with 100 tons of sand per day.

The moulding boxes are knocked out at the knock-out A, slightly to the left and not included in the illustration, the sand falling through the grid fitted in this knock-out, on to an inclined apron conveyor B. This conveyor then discharges the sand into a rotary screen C, an adjustment being fitted to the apron conveyor so that the feed can be regulated. The rotary screen is of the latest centre-shaft driven type and removes the oversize, which consists of large pieces of iron, coke, etc., and these are discharged down a tailings shute into a collecting crane-handled tub. The screened sand then passes through the de-silter, and all dust and silt is extracted from the sand and recovered at the discharge of the exhausting cyclone D for easy transport to the refuse tip. The de-silter is adjustable so that the degree and quantity of silt extracted can be varied at will. The screened and silt-free sand then falls on to a collecting magnetic belt conveyor E beneath the screen, and after passing over a magnetic head pulley, which removes the finely divided iron, is then discharged into the boot of a totally-enclosed bucket elevator F. The sand is thus elevated and discharged into the basis sand-storage hopper G, which is capable of holding 18 tons of sand. At the base of this basis sand-storage hopper is fitted a door, and the necessary quantity of cleaned, old foundry sand is discharged from the hopper into the bucket of the loader H. The correct proportion of new sand is then added by hand to the basis sand already in the bucket, the bucket is then elevated and discharges its contents into a No. 3 size August's Simpson intensive sand mixer I. The mixer is of August's latest design, and is fitted with mullers and ploughs; the mullers are adjustable and can be raised or lowered, if necessary, to eliminate the possibility of any grinding action on the sand.

The correct amount of water, controlled by a meter O, is then added to the charge of sand whilst mixing. The mixer is fitted with two discharge doors in the base of the pan, and when mixing is complete the sand is automatically discharged through one door into the waiting crane-handled tub or truck for general foundry use, or through the other discharge door directly into a rotary feeding hopper J. Each discharge door is fitted with a No. 3 size pin-type aerator K, and the mixed charge of sand is automatically aerated in its passage to the waiting crane-handled tub or rotary hopper.

The rotary feeding hopper is fitted with an adjustable sleeve and plough, and is set to give a continuous stream of sand into the boot of an elevator L. The mixed sand is then elevated and discharged into one of the two 10-ton storage hopper M, from which the mixed sand is drawn for the Sandslinger N.

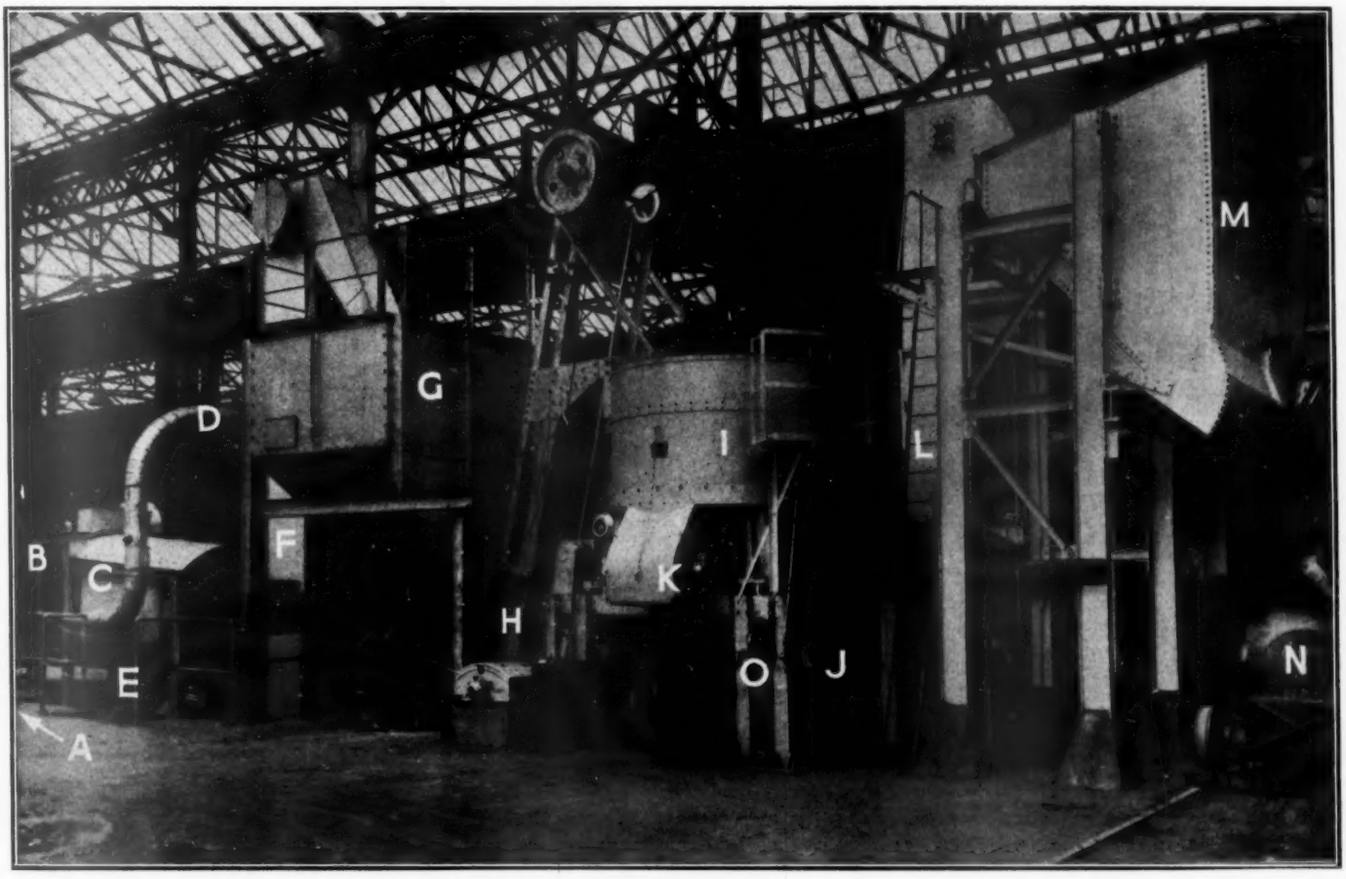


FIG. 1.—THE SAND PREPARING PLANT AT THE CATHCART FOUNDRY OF G. & J. WEIR, LIMITED.

Catalogue Received

Magnetic Separators. The Rapid Magnetting Machine Company, Limited, of Magnet Works, Lombard Street, Birmingham, 12, have used a 12-page brochure to describe and illustrate two types of separators known as "Rapid" (Type O) and "Rapidity" designed to deal with feebly-magnetic ores. It is illustrated by both sketches and photographs of actual machines and performances on various types of material are given as figures related to belt-feed speeds. As there are not many manufacturers of magnetic separators it is suggested that the brochure would fulfil its purpose equally well if it gave the impression that competitors simply did not exist. It is good salesmanship to be ignorant of competition unless it is forced upon one during an actual interview. Readers sending for this catalogue would be well advised to ask for other literature published by this firm as this particular one deals with feebly-magnetic ores, and foundry sand does not enter this category. The magnetic treatment of foundry sand, we believe, is the subject of a special publication, as the issuing house has specialised for many years in this direction.

A New Process of Smelting Foundry Pig-Iron*

DESULPHURISATION PHENOMENA INVOLVED

By MAX PASCHKE and EUGEN PEETZ

Iron ores can only be successfully smelted if not too much limestone be required to fix whatever sulphur is present in the ore and coke. It is true that calcining and sintering have been found to be effective media for the desulphurisation of ore prior to smelting, but, as is known, the requisite amounts of limestone and slag proportionately increase with the acidity, and particularly as the silica content of the ores. Hence in ordinary blast-furnace practice, these latter cannot be worked up economically on account of the low yield and high coke consumption. This is a grave defect, because there are many ores of this kind which present interesting problems both to the metallurgist and to those charged with their preparation. Attempts are made by a variety of preparation methods to free the ores of their excessive acidity, but this entails the irretrievable loss of the comparatively large amounts of iron in the slags. A process developed by the Iron Research Institute at Düsseldorf[1] will probably render valuable services

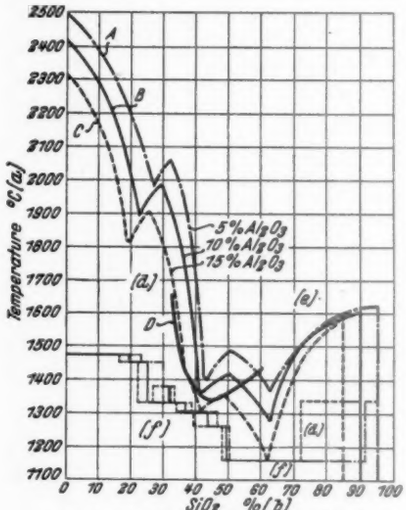


FIG. 1.—A, B, C, MELTING POINTS OF PURE SiO_2, Al_2O_3 AND CaO SLAGS WITH 5, 10 AND 15 PER CENT. Al_2O_3 RESPECTIVELY. D, FREE RUNNING TEMPERATURES OF BLAST-FURNACE SLAGS WITH 12 TO 15 PER CENT. OF Al_2O_3. *a* = TEMPERATURE DEG. C.; *b* = SiO_2 PER CENT.; *c* = CaO PER CENT.; *d* = SOLID AND LIQUID; *e* = LIQUID; *f* = SOLID.

in many instances, as does the Krupp-Renn process.[2] In this case the ores are worked up by way of sponge into iron in a rotary tubular furnace with the formation of a beneficiated product bedded in a pasty slag.

The authors have broken perfectly fresh ground. Liquid pig-iron and liquid slag are produced in the blast furnace from a burden high in acids or sulphur with more or less high-sulphur coke. Slag-formers, such as limestone, are added only in such amounts as to produce, in addition to an easily melting acid slag, a high-sulphur pig-iron which, after tapping, is desulphurised by means of a basic slag or by other usual procedures.[3]

* A Paper presented to the International Foundry Congress at Düsseldorf.

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New Process Indicated

The method is based on a new idea running counter to the opinions hitherto held by blast-furnacemen, inasmuch as desulphurisation in the furnace is deliberately abandoned, the sulphur being removed from the iron by suitable means only after the latter has been tapped.[4] This results in less limestone, a smaller volume of slag and a reduced coke consumption. Due to the increased acidity, the slag is more fluid. There is, however, a limit to this; if the lime reduction be considerable, the slag may become so viscous that it will not flow out of the furnace. Silica, alumina and lime, all according to the percentages present, mutually affect the melting point[5] (see Table I) to a considerable degree, whilst other ever-present fluxes, such as ferrous and manganese oxides and alkalis, have a powerful effect in lowering the melting point.

TABLE I.—*Compositions and Melting Points in the Ternary System* CaO–Al_2O_3–SiO_2.

SiO_2. Per cent.	Al_2O_3. Per cent.	CaO. Per cent.	Melting point. Deg. C. ± 5 deg.
6.9	41.8	51.3	1,350
18.2	30.9	50.9	1,335
21.8	37.19	40.83	1,590
33.0	36.8	30.2	1,385
41.0	11.8	47.2	1,310
41.2	13.2	45.7	1,360
42.0	20.0	38.0	1,265
43.38	36.63	20.09	1,550
47.3	18.6	34.10	1,299
62.0	14.7	23.3	1,165
70.0	19.5	10.5	1,359
70.4	19.8	9.8	1,345

Thus, the melting points found by Rankin (Fig. 1) for pure SiO_2-Al_2O_3-CaO mixtures containing 5, 10 and 15 per cent. Al_2O_3 respectively provide noteworthy information. In each of the three curves the alumina is constant, whilst the silica is variable, and the amount of lime added is the difference between 100 and the sum of the two other components. In Fig. 1 there have been inserted the free-running temperatures found by J. E. Johnson, jun., for blast-furnace slags containing from 12 to 15 per cent. Al_2O_3. Here it is a question not of melting-points, but of temperatures at which slags of varying SiO_2 contents flow freely. By a comparison of the curves C and D the difference between melting points and free-flowing temperatures is obvious.[6] In judging the fluidity of a slag, it is not sufficient to adduce the melting point without taking other factors into consideration. It is important that this point be definitely established, because from the position of the melting points one cannot draw any inferences as to the viscosity of the slags and in any case the melting points of industrial slags are considerably higher in an oxidising than in a reducing atmosphere.[7]

Melting Points of Slags

Fig. 2 shows the free-flowing temperatures of blast-furnace slags containing 12 to 15 per cent. Al_2O_3 as a function of SiO_2 contents ranging from 32 to 60 per cent. The temperature minimum lies at 44 per cent. SiO_2 (CaO : SiO_2 = 1). In the basic conditions the temperatures increase rapidly, whereas in the acid conditions (charcoal blast-furnace slags) the curve is flat. For ordinary coke blast-furnace slags the proportion CaO : SiO_2, on account of the sulphur, is always greater than unity, the average being 1 : 5, which corresponds to a SiO_2 content of 34 per cent. (generally even lower). The relevant free-flowing temperature is 200 deg. C. higher than it is for 44 per cent. SiO_2. According to this, the hearth temperature can be kept lower than usual in the case of acid melts. The sulphur is picked up by the pig-iron to a greater degree than in the basic process, the volume of slag influencing this extensively. As siliceous materials frequently contain very low percentages of alumina it may, in certain circumstances, be expedient to add to the burden aluminous

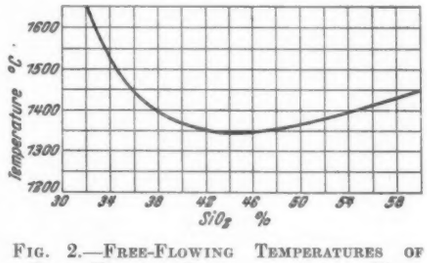


FIG. 2.—FREE-FLOWING TEMPERATURES OF BLAST-FURNACE SLAGS, CONTAINING 12 TO 15 PER CENT. Al_2O_3.

ores, *e.g.*, low-grade bauxite, for the purpose of obtaining with the requisite amount of limestone a free-flowing slag.

If the percentages of silicon and alumina in the slag be about the same, or even if the latter preponderates, then one may expect a low-silicon, sulphurous pig-iron. With higher percentages of ferrous oxide in a highly siliceous slag a high-sulphur low-carbon pig-iron is obtained. Table II provides an example, for there

TABLE II.

Sulphur-bearing pig-iron. Per cent.		Acid slag. Per cent.	
P	1.83–2.03	Fe ..	1.25– 3.60
Mn	0.20–0.25	Mn ..	0.24– 0.60
Si	1.32–2.30	P ..	0.04– 0.11
S	0.19–0.51	SiO_2 ..	41.00–42.10
C	2.76–3.15	Al_2O_3 ..	11.84–12.30
		CaO ..	37.20–39.65
		MgO ..	2.21– 2.41
		S ..	0.62– 0.90

the volume of slag per ton of pig-iron is very great. Smaller volumes of slag of identical percentage composition increase the sulphur in the pig-iron. Summarising, it may be said that the more silica and ferrous oxide there is in the slag—always provided that it is quite liquid—the more sulphur and the less carbon there will be

in the pig-iron. The percentage of silicon in pig-iron is a function not only of the available supply of the former in the slag, but also of the hearth temperature. The throughput time will be shorter with free-flowing acid slag than with basic slag, provided always that the physical condition of the two burdens is identical and good, and that in both cases the amounts of slag are the same. The fact that one does not need to desulphurise in the blast furnace makes for easier running.

Oxygen-Enriched Blast

Of late the production of oxygen has been made very much cheaper.[8] The results obtained with an experimental blast furnace using blast enriched with oxygen proved quite successful,[9] and for this reason the employment of this procedure for acid blast-furnace conduct appears promising. Using oxygen, the coke consumption will spontaneously decrease, and since it would be easier to arrive at the required free-flowing temperatures of highly acid slags, a further increase in their acidity is rendered possible. Due to the reduction in coke consumption, the furnace ash—which is invariably acid—will have a lower sulphur content. The yield of iron will improve, although this will involve increased silicon reduction, but in any case this is desirable in making foundry pig-iron.

The high-sulphur pig-iron produced by this process is desulphurised, as far as possible, immediately after tapping, as long as it is still fluid, by known methods, *e.g.*, a suitable basic slag or manganese. The need for bases is slight, as the bulk is rendered ineffective by the acid in the furnace. Sodium oxide is increasingly important as a base for the manufacture of foundry pig-iron, and it may conveniently be added in the form of soda ash.

Experimental Data

Before considering acid smelting the authors studied the problem of desulphurisation, and that particularly because they were hoping to obtain a pig-iron containing up to 1 per cent. of sulphur and they had no data for the desulphurisation of such amounts. Cast iron with a sulphur content of 0.10 to 0.15 per cent. and pig-iron with less than 0.10 per cent. (10 and 11) are commonly desulphurised, and for this purpose from 0.5 to 1 per cent. of soda ash is necessary. They then proceeded to determine in the laboratory the optimum desulphurisation conditions for the high-sulphur pig-iron using soda ash.

In order to avoid troublesome subsidiary reactions the authors used a crucible material which withstood alkaline slags and for this purpose they found that dead burnt sintered corundum crucibles were extremely suitable as they absorbed no slag and were only attacked slightly. On account of their susceptibility to changes in temperature the crucibles had to be very carefully heated and cooled. The heats were carried out in an electrically heated carbon-tube or Tammann type of furnace. The vapours that arose on desulphurising with soda ash made it impossible to measure the temperature optically and hence a platinum/platinum-rhodium couple was used. The protective tube or sleeve, which was of sintered corundum, served for stirring the melts.

At each experiment approximately one kilo of iron that had been made in a high-frequency furnace was melted and was of the following composition: 2.58 C; 2.07 Si; 0.16 Mn; 0.26 P and 1.7 per cent. S. The manganese was purposely made low because pig-iron made by the acid process is generally low in manganese. By the addition of 50 per cent. ferro-silicon the silicon content increased to over 3 per cent. During the process of melting down a considerable proportion of the sulphur escaped as sulphur dioxide so that on reaching the necessary temperature the iron had only the desired 1 to 1.3 per cent. of sulphur. After regulating the temperature, which they could do to within ± 20 deg. C., the melting slag was removed, a sample of iron taken and soda ash then added. In calculating the amount of soda ash allowances were made for losses and for the weight of the iron sample. The alkali was added gradually, in small quantities at a time, to avoid too violent reactions and consequent losses of soda ash.

Table III.—*Progress of Desulphurisation with Soda Ash at* 1,200, 1,300 *and* 1,400 *deg. C. as a Function of Time.*

Test No.	Amount of soda ash added. Per cent.	Amount of soda ash added. Min.	Temperature. Deg. C.	S and Si content of pig-irons after treatment. Per cent.	0 min.	15 min.	30 min.	45 min.
15	6.1	10	1,200	S ..	1.01	0.035	0.040	0.050
				Si ..	3.68	2.60	2.50	n. e.
14	6.2	12	1,300	S ..	1.02	0.050	0.050	0.060
				Si ..	4.82	3.24	3.07	n. e.
16	6.1	14	1,400	S ..	1.15	0.090	0.080	0.070
				Si ..	4.27	3.42	3.20	n. e.

An outstanding advantage of desulphurising with soda ash is the shortness of the reaction period. The delaying factor in metal-slag reactions is not so much the chemical reaction speed *per se*, which at high temperatures is known to be very fast, as the slow equalisation of concentrations, particularly in the slag phase. Advantages in the use of soda ash are (1) the high fluidity of the resulting slag and (2) the evolution of gases (CO and CO_2 respectively from the dissociation of the soda ash) which agitate the slag, similar to the boiling in an open-hearth furnace. With thin slag blankets the stirring effect of the escaping gases is sufficient in itself, whilst with thick blankets the reaction periods may be notably shortened by additional mechanical stirring to enhance the equalisation of concentrations.

Influence of Time

In order to ascertain how desulphurisation progressed with time at temperatures of 1,200, 1,300 and 1,400 deg. C., samples of iron were taken and tested 15, 30 and 45 minutes after the commencement of the soda ash addition, which itself took 10 to 14 minutes (see Table III). In all three cases the main reactions were complete within a few minutes of the end of the soda-ash addition. Under other circumstances and particularly if the melt were not stirred the reaction period would be somewhat different, yet it can be inferred from the experiments that even with heavy additions of soda ash the required time for desulphurisation is quite short, provided that there be good equalisation of concentration. After a further 15 minutes, resulphurisation had begun at 1,200 and 1,300 deg. C. due to increasing reaction with the crucible material which had an acid effect. At 1,400 deg. C. one could still determine a slight reduction in the sulphur content 45 minutes after commencing to add the soda ash, although it was at this point that one would have expected the reaction to proceed more quickly and a prompter inception of resulphurisation corresponding to the greater wear of the lining. Possibly this is to be ascribed to higher sulphur losses in accordance with the equation $2Na_2S + 3O_2 = 2Na_2O + 2SO_2$.

As Bardenheuer and Ostermann[10] found, the desulphurising capacity of the soda ash decreases with increasing temperatures on account of the increasing vaporisation losses (Table III), although within the ranges of temperature examined the differences are inconsiderable. After 15 minutes 96.5 per cent. of the sulphur originally present had been removed at 1,200 deg. C., whilst at 1,300 deg. C. the figure was 95.1 per cent. and at 1,400 deg. C. it was 92.2 per cent. The low reaction temperatures required for the treatment with soda ash and the short reaction periods permit of the desulphurisation of a pig-iron immediately after tapping, thus taking advantage of its physical heat. A pig-iron containing 1 per cent. of sulphur can, by a 6 to 7 per cent. addition of soda ash, be sufficiently desulphurised, *i.e.*, below 0.04 per cent. (Table III). Table IV gives the results of experiments to determine the degree of desulphurisation attainable at 1,300 deg. C. with soda ash additions of 3, 5 and 10 per cent., and, for comparison, the figures for a 6 per cent. addition are also included.

Heavy Sulphur Reductions

In all the cases under review the original sulphur content of the pig-iron was approximately 1 per cent. Naturally, the degree of desulphurisation was better with increasing soda ash additions, and when the latter reached 10.7 per cent., the final sulphur, after a comparatively short reaction, was actually as low as 0.007 per cent.—a result otherwise only attainable under a carbide slag in the electric furnace. Soda ash in excess increases silicon losses. Its efficiency decreases with an increase in the quantity used and with an increase in the intensity of desulphurisation. By efficiency is understood the proportion between the amount of soda ash theoretically required to fix the removed sulphur and the amount actually consumed. For fixation as sodium sulphide 1 kilogram of sulphur requires theoretically 3.306 kilos of soda ash, whereas 1 kilo of the latter is capable of fixing 0.3024 kilos of sulphur. This represents a limiting case which is unattainable in practice, because, apart from the vaporisation losses, a portion of the sodium oxide is released by the silica that is formed, and so withdrawn from the sulphide formation resulting in the establishment of an equilibrium according to the equation $FeS + Na_2O \rightleftharpoons Na_2S + FeO$.

Table IV.—*Desulphurisation with Varying Amounts of Soda Ash at* 1,300 *deg. C.* (*Reaction Period* 15 *min.*).

Test No.	Soda ash addition. Per cent.	S reduction with pig. Before. Per cent.	S reduction with pig. After. Per cent.	S reduction referred to: Pig-iron. Per cent.	S reduction referred to: S. Per cent.	Soda ash for S fixation. Per cent.	Efficiency in use of soda ash. Per cent.
13 ..	3.1	0.995	0.250	0.745	74.8	2.46	79.4
12 ..	3.2	0.950	0.270	0.680	71.6	2.25	70.2
10 ..	5.3	0.975	0.075	0.900	92.3	2.97	56.2
14 ..	6.2	1.020	0.050	0.970	95.1	3.21	51.7
9 ..	10.7	0.970	0.007	0.963	99.3	3.18	29.7

With a 3 per cent. addition of soda ash, the efficiency is almost 80 per cent., whereas for 10 per cent. of soda ash the figure is no more than 30 per cent. Approximately 1 per cent. of soda ash makes 1 per cent. of slag. To balance the loss of weight due to evaporation and the evolution of the carbon dioxide, there is an almost equivalent increase due to the absorption of FeO(FeS), MnO(MnS) and SiO_2. Actually, the consumption of soda ash for the fixation of sulphur is somewhat less, because a portion of the sulphur in the slag escapes as sulphur dioxide and a certain amount of iron- and manganese-sulphide will be present in the slag.

Multi-stage Desulphurisation

The higher cost of soda ash as compared with the more common desulphuriser, lime, makes it necessary to increase the efficiency of the former to the utmost possible degree. This efficiency decreases rapidly as the degree of desulphurisation increases. A saving can be effected if desulphurisation is done not in one stage as was the case in all the experiments hitherto described, but in two. The authors carried out a series of desulphurisation tests in a number of stages (Table V). In these cases the sulphur contents of the pig-irons prior to the addition of soda ash were higher than in the former experiments, being from 1.2 to 1.3 per cent. In the first two experiments they worked in two stages, and in the third in three. In experiments Nos. 3 and 5 the sulphur content of the pig-iron in the first stage (5 per cent. soda ash) fell to 0.25 per cent. and 0.14 per cent. respectively, and in the second (5 per cent. soda ash) to 0.015 per cent. and 0.005 per cent. With single-stage desulphurisation (No. 9 in Table IV), 10.7 per cent. of soda ash removed 0.96 per cent. of sulphur. Approximately the same amount of soda ash added in two stages removed 1.28 per cent. and 1.18 per cent. respectively. In experiment No. 9 the "efficiency" was 29.7 per cent., whereas in No. 3 it was 42.3 per cent. and in No. 5 it was 38.9 per cent. Actually only experiments Nos. 3 and 5 are comparable, because there the final sulphur contents in the irons were almost the same. In experiment No. 1 desulphurisation was carried out in three stages, successive additions of 2, 5 and 2.7 per cent of soda ash being made. In this case the "efficiency" was 43.1 per cent. Preliminary practical experiments with from 1 to 12 tons of iron having similar sulphur-contents essentially confirmed the laboratory findings.

TABLE V.—*Desulphurisation with Soda Ash by Stages.*

Test No.	Stage	Soda ash addition. Per cent.	Temperature. Deg.C.	Reaction period. Min.	Pig-iron. Per cent. C.	Si.	Mn.	S.	S reduction. Per cent. In pig.	In S.	Si reduction. Per cent. In pig.	In Si.	Slag. Per cent. Fe.	Al_2O_3.	SiO_2.	S.
3	—	—	1,300	—	2.35	3.58	0.100	1.295	—	—	—	—	—	—	—	—
	I	5		13	2.49	2.82	0.073	0.250	1.045	80.7	0.76	21.2	15.8	4.30	24.70	15.78
	II	5		15	2.57	1.88	0.071	0.015	0.235	18.1	0.94	26.3	1.68	4.46	35.70	7.36
								Σ	1.280	98.8	1.70	47.5				
5	—	—	1,300	—	2.52	4.64	0.098	1.180	—	—	—	—	—	—	—	—
	I	5		15	2.55	3.53	0.082	0.145	1.035	87.7	1.11	23.9	11.9	3.61	26.90	20.61
	II	5		15	2.55	2.82	0.081	0.005	0.140	11.9	0.71	15.3	1.28	8.77	34.10	5.86
								Σ	1.175	99.6	1.82	39.2				
1	—	—	1,300	—	2.40	4.33	0.110	1.290	—	—	—	—	—	—	—	—
	I	2		10	2.55	3.48	0.073	0.640	0.650	50.4	0.85	19.6	27.3	4.24	19.70	14.66
	II	5		10	2.55	2.50	0.072	0.045	0.595	46.2	0.98	22.6	3.55	5.72	31.65	13.02
	III	2.7		6	2.53	2.27	0.073	0.025	0.020	1.6	0.23	5.3	1.19	7.07	31.00	7.00
								Σ	1.265	98.2	2.06	47.5				

Iron Added to Molten Soda Ash

In industrial practice it is possible to shorten the reaction period materially by allowing the iron to flow into a ladle in which the necessary soda is present in liquid form. As a precautionary measure to ascertain that under these conditions the reactions would not be too violent, 19 kilos of soda ash were melted down in a high-frequency furnace whose crucible had been strongly heated up by a previous melt of iron, and then about 20 kilos of high-sulphur cast iron were added through a runner at a temperature of 1,250 deg. C. The reactions proceeded without the slightest danger, and it was soon evident that this method of procedure was the most convenient if properly applied to large-scale operations. In connection with acid melting in the blast furnace using single-stage desulphurisation with 2 to 3 per cent. of liquid soda ash, reference is made to a number of results as reproduced in Table VI.

In large-scale practice where the pig-iron is low in sulphur it has been found advantageous to employ the soda ash in dense, granulated and practically dustless condition, otherwise there would be considerable amounts of soda ash carried off by the draft from the evolving gases. If the sulphur contents are higher it is preferable, in order to avoid too intensive cooling, to allow the pig-iron to flow into the ladle containing molten soda ash of ordinary commercial quality which has been melted down in a special vessel. One may also use a desulphurisation receiver capable of being heated, *e.g.*, in the form of a pig-iron mixer. This offers the advantage that the liquefaction of the commercial soda ash and the desulphurisation of the iron take place in the same vessel, and that alkali losses due to spitting are reduced.

Question of Refractories

Even where desulphurising by means of soda ash is carefully carried out it will be impossible to avoid slight discrepances owing to fluctuations due to atomisation, decrepitation and vaporisation and the thinly liquid slag penetrating the pores and joints of the material of which the crucible or ladle is made. The losses from atomisation and decrepitation are particularly heavy where too much soda ash is added at one time. The soda ash should be added in granulated form and in successive small doses. Again, in order to reduce vaporisation losses the reaction-temperature should not be too high. The addition of lime would assist in this direction, but then one would have to endure the consequent lesser reactive capacity. Penetration of the slag into the refractory material can be checked by having the latter dense and keeping the brick-joints narrow. It is for this reason that, for practical purposes, dense fireclay bricks are used. Such material is essential from the point of view of soda-ash losses and lining-wear, especially as acid components of the lining dissolved by the slag have a most deleterious effect upon desulphurisation. In the slags from the experiments the authors found alumina contents of 2 to 9 per cent. and even more—both the crucible and the protective sintered corundum tube being attacked. The formation of sodium aluminate deprived some of the alkali of its desulphurising effect. In foundry practice where, owing to lower sulphur contents, there is less formation of soda-ash slag, densely burnt fireclay bricks have proved relatively satisfactory, yet they are still slightly attacked by the highly basic slag—sodium aluminate—and silicate is formed. If the bricks be insufficiently resistant these may easily be resulphurised.

The results of experiments to test the attack by molten soda ash on fireclay bricks[13] are instructive. Bars of square section (length of edge 25 mm.) sawn from ordinary bricks were allowed to dip to a depth of about 50 mm. into the slag so as to be subject to attack on all sides. The tests were discontinued after 6 hours as by that time the difference in behaviour of the various qualities of brick was manifest (Table VII). Ladle-bricks Nos. 1, 2 and 3, which were of three different volume-porosities, proved most resistant to attack by molten soda ash, the densest brick of all (8 per cent. volume-porosity) showing scarcely any signs of attack. The high-alumina bricks Nos. 4 and 5 are quite useless for this purpose because they swell and disintegrate. Bricks of medium porosity (Nos. 6 and 7) and alumina-contents are badly damaged. Brick No. 8, despite its high alumina content and porosity, behaved better: it is evident that fire-stone* is more resistant to molten soda ash. Since during desulphurisation the bricks are exposed to a slag containing iron and high percentages of silica and soda ash, it was decided to test their resistivity, using bars of the same dimensions and quality as before. Here the attack is more violent than in the case of the soda ash alone, especially as the reaction-temperature was 100 deg. C. higher. The differences in behaviour of the various qualities are very clear. The densest ladle-brick behaves best. These tests have shown that bricks of medium alumina content and particularly those of great density show the best resistance to molten alkali and high-alkaline slags. No data so far as is known have yet been collected regarding magnesite bricks, which from their basic character would appear particularly suitable, but the high price and susceptiblity to changes of temperature would militate against their employment.

Lime Additions to Soda Ash

An obvious suggestion is to mix the relatively expensive soda ash with cheap lime, although this reduces the fluidity of the slag and hence its reactive capacity. Using mixtures of 5 per cent. soda ash and 1 per cent. lime and 4 per cent. soda ash with 2 per cent. lime respectively no noteworthy improvement in desulphurisation was observed. On the other hand, when soda-slags that had finished reacting were primed with lime, quite notable degrees of desulphurisation were obtained. Thus in experiment No. 15 (Table III), 1 per cent. of CaO was added after

TABLE VI.—*Additions of from 2 to 3 per cent. of Molten Soda Ash.*

Test No.	Pig-iron. Tons.	Reaction period. Min.	Temperature. Deg. C.	Pig-iron. Per cent. C.	Si.	Mn.	P.	S.	S reduction. Per cent. In pig.	In S.	Si reduction. Per cent. n pig.	In Si.
A	17.5	15	1,310	2.67	1.66	0.18	1.80	0.508	—	—	—	—
				2.77	0.93	0.08	1.80	0.066	0.442	7.0	0.73	44.0
B	19	20	1,308	3.06	2.36	0.27	1.88	0.205	—	—	—	—
				3.01	1.79	0.22	1.88	0.018	0.187	91.2	0.57	24.1
C	17	15	1,307	3.06	2.31	0.27	1.88	0.190	—	—	—	—
				2.72	2.08	0.22	1.88	0.027	0.163	85.7	0.23	10.0
D	18.5	20	1,302	3.35	0.97	0.18	2.10	0.208	—	—	—	—
				3.35	0.36	0.10	—	0.026	0.182	87.5	0.61	62.9

* Schiefer = shale or slate.

45 minutes and 5 minutes thereafter the sulphur content of the iron decreased from 0.050 per cent. to 0.020 per cent. In experiment No. 16 1.08 per cent. of CaO was added after 45 minutes and 8 minutes later the sulphur content of the pig-iron decreased by 0.02 per cent. For the desulphurisation of cast iron Colbeck and N. L. Evans[14] used a mixture of soda and limestone in the proportion 1 : 0.63-0.75 in order to get a slag that could easily be drawn off. As compared with soda ash alone the desulphurisation was not quite so good. Here the stiffening effect was still further enhanced by the intensive cooling due to the dissociation of the limestone.

TABLE VII.—*Volume Porosities and Alumina Contents of Firebricks.*

No.	Volume porosity. Per cent.	Al_2O_3 Per cent.	No.	Volume porosity. Per cent.	Al_2O_3 Per cent.
1	8	38	5	19	62
2	12	38	6	23	31
3	15	38	7	26	38
4	18	50	8	29	44

Oxidising treatment of the slag during the process of desulphurisation should also be considered. However, treatment with air or waste gas offers no prospect of success unless the favourable effect of sulphur-dioxide formation outweighs the deleterious effect of a possible oxidation of the bath of metal. It is good practice to use the fine desulphurising slag for coarse desulphurisation. Where desulphurisation is carried out in stages the procedure referred to makes for high "efficiency" combined with intensive sulphur enrichment of the slag. Thus an iron containing 1.42 per cent. of sulphur was reduced to 0.77 per cent. by the addition of 5 per cent. of used soda-ash slag. The absolute reduction in sulphur was thus 0.65 per cent. and the percentage reduction 45.8 per cent. Similar figures were found in further experiments.

Treatment of Resulting Slags

The slags that occur on desulphurising with soda ash are hygroscopic and produce considerable amounts of hydrogen sulphide. Apart from the difficulty there would be in accommodating them, the valuable alkalis and sulphur they contain would merit their utilisation. A remedy that suggests itself is to recover the alkalis from the slag in the form of soda ash by a known process, for which purpose the slag has to be brought into an aqueous solution into which carbon dioxide is introduced. An experiment made as far back as 1934 showed that partial regeneration is fundamentally possible. Under certain circumstances the slag can be made to yield sodium silicate and sodium sulphide.

The acid blast-furnace slag can, by suitable treatment, be used for the manufacture of slag-wool and paving stones. The use of ordinary blast-furnace slag to make glassware[15 16] is, of course, known, but for this the acid slags are still more suitable, especially when mixed with a corresponding quantity of desulphurising slag with a high lime content. When such a mixture is made, considerable amounts of sulphur are driven off; thus when 50 per cent. of silica was added to a desulphurisation slag which had completed its reactions, the sulphur content fell from 15.78 per cent. down to 4 per cent., and, when air was blown on to it, to 0.12 per cent., the temperature being 1,300 deg. C.

The reason for choosing a pig-iron of particularly high sulphur content for the laboratory experiments was to facilitate the study of desulphurising conditions in an extreme case. In the acid smelting process, too, according to the acidity and the volume of the slag, one may get low-sulphur irons for the desulphurising of which less soda ash will naturally be required. As compared with the basic blast-furnace process the cost of manufacturing the pig-iron decreases when that of desulphurisation is less than the saving effected in the acid process. This was proved by a large-scale experiment in a blast furnace using nothing but low-quality ores.

Induced Beneficial Results

Not only does the soda ash desulphurise pig-iron but it also leads to a remarkable improvement in quality, which is an advantage in the case of foundry pig-iron. The graphite is finely distributed just as it is in soda ash treated cast iron.[11] In laboratory experiments made by the authors a synthetic high-sulphur and low-carbon foundry pig-iron revealed, after desulphurisation, a pearlitic matrix with finely divided graphite. A pig-iron with the lowest practicable silicon content made by the process just described can also be used for the manufacture of basic-Bessemer steel. In a very informative Paper entitled "Metallurgical Problems and Possibilities of Adjustment to the Raw-Material Position,"[3] H. Bansen has described the part played during the "blow" by a basic-Bessemer pig-iron with high-sulphur and low-manganese contents. An alternative is to remelt solid sulphurous iron in the blast furnace with basic slag that is not saturated with sulphur. This applies particularly to plants having to work with fairly large amounts of slag in the ordinary process owing to the nature of their ore. This is an advantage, because the silicon content of iron produced will not exceed the usual limits. It has already been proposed that use be made of the same method of desulphurising the beneficiated product obtained in the Krupp-Renn process. Desulphurisation in large electric furnaces might be considered if the cost of current were low.

Desulphurising by Means of Manganese

If a sulphurous pig-iron be mixed with one high in manganese the resulting product is a low-sulphur iron with a slag high in manganese.[3] The following remarks may serve further to explain this: One blast furnace is run on high-sulphur pig-iron and the other on spiegel. If, now, the volumetrically adjustable tappings from both furnaces be allowed to run together into one ladle the high-sulphur pig-iron will be desulphurised by the manganese in the second iron, manganese sulphide being formed. Since during tapping into a second ladle or a mixer a portion of the sulphur burns to sulphur dioxide, the consumption of spiegel will decrease to an amount to be fixed by experience. In this way, therefore, one can improve the sulphurous iron, admittedly at the cost of depreciating the spiegel down to a low-manganese open-hearth pig-iron. It is quite possible to lower still farther the manganese content by the addition of molten high-sulphur iron. It goes without saying that the sulphur in the new iron must not exceed the permissible limit, for the proportion of silica to manganese in the slag in process of formation must not exceed 0.80, otherwise one may expect resulphurisation.[17] This is an important point if it be desired to utilise to the utmost degree the manganese content for desulphurising an iron.

Owing to its high melting point, the resulting slag solidifies very quickly and liquid iron—recognisable as iron granules after solidification—is entrained. This disadvantage is surmounted by adding fluxes, such as molten soda ash, in such a way that these form a blanket on the manganiferous pig-iron before the sulphurous iron is added. The consumption of soda ash on the laboratory scale was approximately 0.2 to 0.3 per cent., whilst in practical experiments it came to 0.5 per cent. of the total pig-iron (Table VIII). In this way it is possible, starting with a high-sulphur pig-iron made from acid ores, and using one with a high manganese content, to produce an iron having any desired percentage of manganese and at the same time to get a liquid slag, which, after water-granulation and calcination, should provide a valuable portion of the ferro-manganese burden.

Production Possibilities

By the process described at the outset, the following varieties of pig-iron can be manufactured:—

(1) High-silicon basic pig-iron (OM) to which any necessary additions (phosphorus in the burden) are made. Subsequent soda ash treatment.

(2) Basic pig-iron (OM) containing ordinary percentages of silicon. Subsequent soda ash treatment.

(3) Basic pig-iron (MM) made by remelting sulphurous pigs in a second blast furnace. Basic slag used with manganese in the burden.

(4) Open-hearth pig-iron (less than 0.25 per cent. P, otherwise heavy reduction in value). Manganese as desulphuriser.

(5) Foundry pig-iron of any desired silicon content, depending on slag technique and temperature. Subsequent treatment with soda ash.

(6) Hematite pig-iron as in No. 5 above if the ores are low in phosphorus. Subsequent treatment with soda ash.

The new process differs from that generally used mainly in the poorly desulphurising acid character of the slag and the high sulphur content of the pig-iron. It can also be used for the smelting of other acid ores, *e.g.*, those containing high percentages of titanium oxide, alumina and sulphur. It permits also of using high-sulphur coke, *e.g.*, lignite coke of good strength and suitable combustibility, regarding the manufacture of which there are already certain pointers which appear to promise success.

H. Bansen has stated: "In all mechanical preparation processes a medium enrichment up to 43 to 44 per cent. of iron can only be obtained at the cost of iron losses from 25 to 35 per cent. and still higher phosphorus losses. The apparent raising of the iron content to 48 to 50 per cent.

(*Concluded on page* 459.)

TABLE VIII.—*Desulphurisation with Manganese.*

No.		Si. Per cent.	Mn. Per cent.	P. Per cent.	S. Per cent.	C. Per cent.
I	1,000 kg Hematite (desulphurised) ..	1.23	0.12	0.08	1.46	3.43
	+ 1,000 kg. "Stahleisen"	0.50	6.65	0.15	0.014	4.24
	5 min. after mixing in the liquid	0.84	1.90	0.116	0.034	3.94
II	1,000 kg. Hematite (desulphurised) ..	1.33	0.12	0.08	1.62	3.52
	+ 1,000 kg. "Stahleisen"	0.52	7.86	0.106	0.028	4.72
	Added 25 kgs. solid soda ash 5 min. after mixing	0.85	2.53	0.092	0.034	3.82
III	1,000 kg. Hematite (desulphurised) ..	1.57	0.21	0.100	1.39	3.69
	+ 1,000 kg. "Stahleisen"	0.81	5.64	0.110	0.04	4.35
	Added 10 kgs. of molten soda ash immediately after mixing	1.18	1.34	0.106	0.084	3.32
	5 min. after mixing (3 times)	1.12	1.68	0.108	0.020	3.30

Slag.	Fe. Per cent.	Mn. Per cent.	S. Per cent.	SiO_2. Per cent.	Al_2O_3. Per cent.
I	83.6	7.89	3.79	—	—
II	86.19	6.65	3.43	—	—
III	7.40	36.30	18.30	8.23	0.50

Test Bar Anomalies

After Mr. J. Hepworth had delivered his Presidential Address (printed in our issue of October 29) at the meeting of the West Yorkshire Branch of the Institute of British Foundrymen, there was a discussion on the controversial topic of test bars; their relative value or otherwise, and the problems which foundrymen have to face in regard to them.

The discussion was opened by MR. A. W. WALKER, of Huddersfield (Past-Branch-President), who said the subject for discussion had been named "Test Bar Anomalies." He suggested that "Test Bars *are* Anomalies" would have been more appropriate. He stated that most of the figures of Table I were either "cribbed" or loaned. The first question he wished to ask was, "What is a test bar?"

He considered that a test bar was a piece of cast iron of specified dimensions and shape, which, when stressed to its limit physically, conformed to a particular casting or castings—physically. It was necessary to imagine some particular test bar, so he suggested that the "M" bar, as recommended by the B.S. Institution be considered. This bar was required to withstand a minimum transverse load of 1,950 lbs., with a minimum deflection of 0.15 in., the tensile minimum being fixed at 11 tons per sq. in. Having broken the bar, and obtained figures conforming to the specification, one had either attained results which had shown the physical properties of a casting at its highest physical value, or the figures denoted the value of a casting at its lowest physical strength. If the latter results had been attained, a test bar had been made in its truer sense. If the foundryman were satisfied with the figures denoting the former condition, he had not broken a test bar, but only a piece of iron. He asked if it were possible to cast a test bar showing simultaneously the figures 1,900 lbs. breaking load with 0.15 inch deflection. A test bar could only be a fair representation of a casting, if it represented the casting at its weakest section.

Referring to the question of simultaneous registration of 1,900 lbs. and 0.15 in. deflection, Mr. Walker said this particular bar gave in its behaviour during the period of loading a more accurate range of figures than the old square bar, 1 in. by 1 in. on 12 in. centres. That bar, it may be remembered, demanded a minimum breaking load of 2,000 lbs., with a deflection of 0.125 in. Actually, when the 2,000 lbs. load had been reached, deflections of either 0.07 or 0.08 in. were registered. This 0.01 in. difference always occurred when 1,500 lbs. load had been applied, and once lost was never recovered. In the 1.2 in. round bar, however, when 1,750 lbs. had been applied, a deflection of 0.16 to 0.174 in. occurred, and in a bad bar this may have been 0.14 in. more or less. Most foundrymen to-day work, to a certain extent, to analysis, and test bar specifications are obtained from a great many specimens whose compositions are widely divergent, or the analyses may be similar, and the physical results will vary widely. He asked what the cause of this variation was.

In Table I there are set out in groups a few series of test bar results, the analyses being approximately alike in each group. He used them in an endeavour to show why these variations should occur. He did not suggest that chemical analysis had failed as a means of obtaining regularity in mixing, but thought that possibly some other condition influenced this. As a subject for discussion, he suggested that attention be drawn to the figures in Table I. Referring to the test bar cast from a cold-blast mix, and that of similar analysis cast from a 15 per cent. steel mix, he asked if the results obtained were due to inherent properties and what these were if they did exist. He hoped that sufficient had been disclosed to create discussion, in which participants were expected to answer their own questions. In conclusion, he read a letter from "Dives," which appeared on page 210 of the September 17 issue of THE FOUNDRY TRADE JOURNAL, remarking that he would like "Dives" to come to Bradford some evening and outline more "stray thoughts."

Effect of Position

MR. W. G. THORNTON said Mr. Walker had given an interesting *résumé* of the difficulties foundrymen had in judging the value of test bars. So far as concerned differences in analyses, as shown by Table I, the difference probably lay chiefly in the carbon content. In considering problems of test bars, however, it was important to know something of the position of the test bar in relation to the casting. Unless all the conditions were known, it was difficult to discuss the analyses satisfactorily. He, personally, could always get about three tons more tensile strength when the test bar was taken from the bottom of the casting than when taken from the top.

International Work

MR. F. K. NEATH said he imagined the ideal way of getting a result of a test bar itself would be to make the test bar separately. That would give a result of the bar irrespective of any particular casting—though it would be necessary to see that the final result in the casting was correlated with the test bar. There was still a good deal of controversy on this matter of test bars, and he hoped that some results would be available from the work of an International Test Bar Committee engaged on the matter. During his (Mr. Neath's) visit to Germany, when he represented Great Britain at a meeting at Düsseldorf, he received a long report in French, but owing to the language complication he was afraid the meeting was not very successful. This was a matter which British foundrymen must study, or there was a risk of some of these foreign tests getting into official cognisance.

Inherent Properties

MR. WALKER said he did not think a specification of any test bar necessarily bound one to the two figures. He felt that the factor of inherent properties was a very important one.

MR. NEATH commented that Mr. Walker's phrase was described in a recent article in THE FOUNDRY TRADE JOURNAL by Mr. J. E. Hurst as a resilience factor as indicating this difference between one iron and another.

MR. A. S. WORCESTER said, in his opinion, there was little doubt that the irons produced by slower worked blast furnaces were stronger irons than in the new blast furnaces.

MR. WALKER said he felt that pyrometrical control of temperatures was perhaps the actual solution of these difficulties.

MR. THORNTON said that a further difficulty, in his experience, was that different cupolas gave different temperatures under similar conditions, and he asked how that was to be overcome.

Cast-on and Trepanned Test Pieces

MR. H. ROBERTS said that, in his experience, test bars cast horizontally at the bottom of a casting, with a long bar, gave the most reliable results.

MR. THORNTON said he understood French opinion favoured taking test bars from the casting itself; but even under these circumstances different results were produced.

MR. WALKER agreed that, as far as practicable, test bars should be cast in the casting itself, but in this, as in other operations in the foundry, the human element was concerned, and could account for some of the different results. The question arose as to which value a test bar did represent—the lowest or the greatest strength value.

MR. WORCESTER remarked that there were so many other factors in the production of a finished casting that a test bar was of comparatively little real value as representing the complete casting.

A MEMBER suggested that a test bar was not a great deal of good, and the sooner it was discarded by inspecting bodies the better.

MR. S. CARTER (Huddersfield) said he could hardly agree with the last speaker. Test bars

TABLE I.—*Composition and Physical Properties of Various Cast Iron Test Bars.*

	Gr.C.	C.C.	Si.	S.	P.	Mn.	Pouring temp. deg. C.	Trans. load. Lbs.	Def. In.	Tensile. Tons per sq. in.	Authority or bar size.
Cold-blast mix	—	—	1.6	0.05	0.6	0.9	—	2,865	0.24	19.2	M.
15 per cent. steel mix ..	—	—	1.65	0.09	0.55	0.87	—	2,229	0.2	15.85	M.
25 per cent. steel mix ..	T.C. 3.36	—	1.72	0.11	0.18	0.6	—	3,763	—	17.98	M.
25 per cent. stee and hematite mix	3.30	—	1.75	0.09	0.30	0.7	—	—	—	14.12	M.
A cylinder iron	3.50	—	1.68	0.068	0.40	0.6	—	3,013	—	16.22	M.
No. 1	2.57	0.55	2.06	0.047	0.31	0.61	—	—	—	18.75	"Foundry," April 30, BOLTON.
No. 2	2.57	0.55	2.06	0.047	0.31	0.61	—	—	—	17.76	" "
33 per cent. Scotch, steel, Indian ..	T.C. 3.32	—	1.92	0.10	0.20	0.76	—	—	—	18.90	—
33 per cent. scrap hematite & Indian	3.1	—	2.15	0.102	0.18	0.68	—	—	—	15.43	B. mix.
A cylinder iron	3.38	—	1.89	0.07	0.55	0.80	—	3,259	—	15.32	—
No. 1	3.4	0.52	1.78	0.04	0.27	0.28	1,400	—	—	9.7	McWilliam & Longmuir.
No. 2	3.4	0.52	1.78	0.04	0.27	0.28	1,350	—	—	14.1	" "
No. 3	3.4	0.52	1.78	0.04	0.27	0.28	1,245	—	—	10.6	" "
No. 1	2.81	0.71	1.29	0.121	0.21	0.78	—	—	—.	13.00	McPherran & Kreuger.
B.N.S. mix ..	2.90	0.56	1.27	0.103	0.39	0.71	—	—	—	16.88	T.B.
No. 2	2.54	0.78	1.21	0.11	0.24	0.67	—	—	—	18.30	McPherran & Kreuger.
No. 3	2.38	0.89	1.14	0.105	0.24	0.60	—	—	—	14.60	" "
No. 1	1.07	2.25	1.28	0.07	0.17	0.93	—	—	—	16.80	A series of bars to inspection.
No. 2	1.07	2.25	1.28	0.07	0.17	0.93	—	—	—	11.35	
No. 3	1.07	2.25	1.28	0.07	0.17	0.93	—	—	—	13.82	
No. 4	1.07	2.25	1.28	0.07	0.17	0.93	—	—	—	10.00	

were an indication of good or bad material used in the job. They had their value in that respect.

Material Evaluation

MR. WORCESTER said undoubtedly the quality of the material could be represented by a test bar, but it was difficult to make the engineer realise that the bar did not necessarily represent the working strength of the completed casting. It was, in a modified degree, a test of quality of material. The foundryman may not be able to guarantee the working strength of the casting, but he should be able to guarantee the quality of his material.

The BRANCH-PRESIDENT (Mr. J. Hepworth, M.P.) said it would seem from the trend of the discussion that the test bar could not be taken as necessarily a criterion of strength of the casting; but it was, so far as they knew, the only operative test at the present time. He wondered whether there was an alternative method of ascertaining the strength and physical properties of a casting as well as the quality of material in use.

MR. CARTER said that the results shown by a test bar were absolutely relative and purely a guide to the quality of material.

The BRANCH-PRESIDENT asked if alloy additions were likely to meet the situation by improving the strength and wearing quality of a casting.

MR. NEATH said there were ways of improving iron without adding alloys. He personally had a great regard for the high phosphorus iron as a good wearing iron. It gave a hard constituent in a relatively soft body of ordinary iron.

The BRANCH-PRESIDENT endorsed this view, and said he knew a large firm who secured six times longer wear in valve seatings by doubling the phosphorus content.

MR. CARTER remarked that according to some authorities nickel aided the strength of all sections of a casting; though that was hardly a test of the test bar.

Influence of Copper

The BRANCH-PRESIDENT asked if any member knew the effects of adding a small percentage of copper to the casting—not necessarily the test bar.

MR. NEATH said he believed that copper had similar effects to those of nickel.

MR. WORCESTER said the addition of copper was reputed to be beneficial.

Vote of Thanks

MR. R. D. WELFORD, proposing a vote of thanks to Mr. Walker for opening the discussion, said test bars were one of the bugbears of the foundryman. The test bar could not definitely represent the casting itself. The discussion had perhaps assisted some of those present. Some people regarded test bars as of great value, and others had a poor opinion of them. Inspecting authorities demanded them, and they had to be produced; nevertheless, different conditions had their effects. The most highly scientific man probably could not get similar results from four test bars cast from the same ladle of metal, but if the inspector was satisfied, that seemed to be as much as they could expect. The difficulty was to find a standard of practice which all could follow.

MR. N. W. RILEY seconded the vote of thanks.

MR. WALKER replied that the Brinell test was, to his own mind, the one test nearest meeting all conditions. It was a very severe test. Though they as foundrymen might have many and varied opinions on the value of test bars, they should not leave the engineering industry under the impression that foundrymen were against test bars. The test bar was a means of getting some relative method of working from day to day, despite the admitted variations in results. Their aim should be to obtain a cheaper cast iron without loss of quality and service capacity.

British Oxygen Company Pension Scheme Established

On January 1 this year the British Oxygen Company, Limited, inaugurated a pension fund scheme for sales, clerical and managerial staff. Since then the scheme has been extended to include the workpeople, and on December 1 embodied also the staff and workpeople of subsidiary companies of the British Oxygen Company in this country.

Of the staff, 99.5 per cent. of the men and 85 per cent. of the women employed by the company have become contributory members of the pension fund, and of the workpeople 95 per cent. of the men and 82.5 per cent. of the women employed. As the employees of the company number over 6,000 (including those employed by subsidiary companies) the percentages attained are highly satisfactory, and the best possible testimony to the attraction and equity of the scheme.

Whilst the scheme follows generally the lines of other contributory pension schemes to which the company and the individual employee are contributing, there are several points of special interest and value to the employee. An allowance, for instance, computed at the rate of two-thirds of one year for each year is made for past services from the age of 20 years and onwards since joining the company's service. In the event of ill-health of incapacitating severity, on a medical certificate being submitted to this effect, the pension becomes immediately payable provided the invalid has served for 10 years or more, irrespective of the number of years' contributions made to the fund. In case an employee is retired as redundant after 20 years' service, the pension is payable immediately, provided the employee has attained the age of 55 years (for men) and 50 years (for women).

In the case of the workpeople's fund, members who are paid off on account of lack of work due to bad trade, still remain members for a period of 24 weeks without contributory payment, and continue as such on coming back to work within that period.

Both funds are guaranteed by the British Oxygen Company in the sense that if any loss be incurred at any time it must be made good by the company. They are self-administered by six trustees, in each case, three representing the directors and three the staff or workpeople, and there is a full-time secretary paid by the company. Similar pension funds are also being started in the company's allied concerns in Australia, South Africa and India, and the figures mentioned above do not include employees in these companies.

Output of Pig-Iron, Steel and Finished Products

The British Iron and Steel Federation, in its Statistical Bulletin for October, states that pig-iron production in the United Kingdom in October amounted to 670,300 tons, compared with 650,800 tons in September and 544,300 tons in October, 1935. The total of 6,371,200 tons for the first ten months of the year shows an increase of 19.4 per cent. over the corresponding period of 1935. Steel production in October amounted to 1,060,500 tons, compared with 1,027,000 tons in September and 907,300 tons in October, 1935. The high rate of production attained in October brings the total for the first ten months of the year to 9,677,700 tons, an increase of 19.1 per cent. over the corresponding period of 1935. According to returns received from 145 firms employing 140,988 workpeople, the average weekly earnings per head in September amounted to £3 9s. 9d., compared with £3 5s. 10d. in August and £3 7s. 9d. in July.

Road Transport and the Light-Castings Industry

A further hearing of the application of the White Line Transport Company, Falkirk, for renewal and variation of their A licences was held in Edinburgh on December 2 and 3, before Mr. A. Henderson, chairman of the South of Scotland Traffic Commissioners.

MR. W. WEIR, for the L.M.S. Railway Company, submitted that railway facilities in Falkirk were ample. He criticised the evidence of Mr. C. W. Gibbs, secretary to the applicant company, that the road transport rates had been reduced as a result of railway competition. The railway rates had been reduced only in November, 1935, as a result of road transport reductions. To grant this application would be to give facilities in excess of what was needed.

For the L.N.E. Railway Company, MR. R. GIBSON contended that there was wasteful competition in Falkirk with regard to transport facilities. The railways carried for everyone at published rates. He contended that the manufacturers in the Falkirk area were giving their business to road hauliers because the rates were excessively low. The representatives of iron-founding firms who had given evidence said they got better service from the road hauliers. They were, however, really influenced by the low rates. He denied that excessive breakages and slow service were features of the facilities offered by the railways.

MR. JAMES TAYLOR, solicitor for the applicants, said the Licensing Authority had to be satisfied on three points: (1) That the nature of the work done by applicants had incurred no change during the currency period; (2) that his vehicles were in regular use, and (3) that applicants intended to continue the same business. An existing licence-holder should receive special consideration. The railway companies did not dispute that the applicant satisfied these three considerations. Their case was simply that their traffic was not so great as it might be, and therefore their competitor should be put off the road. Such a case was contrary to the Act and to the spirit of justice.

MR. J. C. CUNNINGHAM, appearing for Mr. W. M. Tripney, Falkirk, whose application was involved with that of the White Line Transport Company, submitted that the objections were incompetent. The railway companies, by repeated objections and appeals, were seeking to prevent Licensing Authorities exercising their discretion except within limits imposed by the railway companies themselves.

A New Process of Smelting Foundry Pig-Iron

(*Concluded from page 457.*)

in subsequent heat-treatment by driving off carbon dioxide and water of hydration makes no alteration whatever in the unfavourable proportion between silica and iron in the concentrate. As a result there is no advantage to the blast-furnace, but only a saving in freight." Hence, when employing the customary methods of ore dressing, it would be to the point, on account of the heavy iron losses, only to rid the crude ore of silica and alumina to such an extent that, after sintering, the method just described would be used, and so keep the fuel expenditure in the blast furnace within practical limits. In a Paper read before the general meeting of the German Foundrymen's Association in September, 1935,[4] M. Paschke pointed out that both these methods could be of mutual assistance.

RANSOMES & RAPIER, LIMITED, have received an order from Stewarts and Lloyds, Limited, for a third large stripping shovel for the works at Corby, Northants. The machine is claimed to be the biggest excavator built in Europe, and weighs 630 tons.

The Week's News in Brief

Trade Talk

THE PATTERNSHOP at the foundry of Wm. Boydell & Sons, Leigh, Lancs, was damaged by fire recently.

JOHN BROWN & COMPANY, LIMITED, of Clydebank, have started laying the keel of "No. 552," sister ship to the "Queen Mary."

AGREEMENT ON THE double day-shift system was reached at a recent meeting of the Welsh Engineers' and Founders' Conciliation Board.

MACKENZIE & MONCUR, LIMITED, Edinburgh, have cast a 14 ft. cylinder for James Bertram & Son, Limited, paper-making engineers, of Leith Walk, Edinburgh.

THE DIRECTORS OF the Laycock Engineering Company, Limited, Sheffield, propose to increase the capital to £300,000 by creating a further 400,000 shares of 5s. each.

ORDERS FOR THREE VESSELS of 9,200 tons each have been booked by William Doxford & Sons, Limited, Sunderland, from Andrew Weir & Company, Limited, London.

AN ISSUE OF ORDINARY SHARES in Allen & Simmonds, Limited, general engineers, will be made shortly under the auspices of the Commercial & General Finance Trust, Limited.

THE ANNUAL GENERAL MEETING of the Sheffield Society of Engineers and Metallurgists will be held on December 14 in the Mappin Hall, St. George's Square, Sheffield, at 7.30 p.m. Dr. H. J. Gough, M.I.Mech.E., will read a Paper "The Mechanism of Fracture in Metals."

SCOTTS' SHIPBUILDING & ENGINEERING COMPANY, LIMITED, Greenock, have received an order from Alfred Holt, Limited, for a twin-screw motor passenger and cargo liner of 10,000 tons deadweight.

THE ENGLISH ELECTRIC COMPANY, LIMITED, have received an order for 99 Diesel rail-cars for the Buenos Ayres Great Southern and the Buenos Ayres Western Railways. The value of the contract is estimated at £400,000.

HURST, NELSON & COMPANY, LIMITED, Motherwell, have received an order from the London & North Eastern Railway for 250 bolster type wagons, and an order for steel underframes from the Chinese Purchasing Commission.

WITH THE DESTRUCTION by fire of the Crystal Palace, the Clyde Foundry of Harland & Wolff, Limited, Helen Street, Govan, is the largest all-glass building in the country. It is 800 ft. long, 600 ft. wide, and 100 ft. high.

SPEAKING AT THE annual general meeting of R. A. Lister & Company, Limited, Dursley, Glos, Mr. Percy Lister (chairman) said that work had commenced on the building of a new foundry, which would be equipped with the latest plant and machinery.

A FIRE OCCURRED at the Tubal Works of Shanks & Company, Limited, Barrhead, last week. It originated in the enamelling department, and spread to an adjoining department, which was also damaged. Arrangements have been made to carry on as usual.

APPLICATION IS TO BE MADE for permission to deal in the shares of John Rigby & Sons, Limited, a company recently formed to acquire an old-established Yorkshire business of manufacturers of iron, steel and brass wire. The capital is £250,000 in ordinary 10s. shares.

WOLVERHAMPTON INDUSTRIAL DEVELOPMENT ASSOCIATION have announced that negotiations have been completed for a new company, the Butro Jig & Engineering Company, Limited, specialising in the manufacture of jigs, dies and precision engineering products, to begin operations in the town.

CALEDON SHIPBUILDING & ENGINEERING COMPANY, LIMITED, Dundee, are to build a motor liner of 10,000 tons deadweight for the Blue Funnel Line of Alfred Holt, Limited. The machinery, consisting of Diesel engines constructed by Burmeister & Wain, Copenhagen, will be installed by the builders.

THE BRITISH ALUMINIUM (AUSTRALIA) PROPRIETORY COMPANY, has been registered in Melbourne, with an authorised capital of £300,000, for the purpose of manufacturing aluminium in Australia. The whole of the capital will be subscribed by the British Aluminium Company, Limited, and the Electrolytic Zinc Company (of Australasia) Proprietary, Limited.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Some Factors Influencing the Production of Sound Castings

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In your issue dated November 26, Mr. Hartley takes exception to the remarks about moulders, appearing in our article in THE FOUNDRY TRADE JOURNAL of November 12.

From Mr. Hartley's remarks, we gather that he is one of the few moulders who can use a vent wire, place a runner correctly, ram a mould or feed a casting without instruction, but we assure him the services of such men are difficult to obtain, and it is to such a type that the authors refer when they state "a responsible official," always assuming that a person having such knowledge is able and willing to use and carry authority.

We would, however, assure Mr. Hartley that at least one of us started his career pushing a foundry wheelbarrow, and worked (for a living) as an apprentice, moulder, coremaker, charge hand and foundry manager, and, in earlier days, had exactly the point of view held by Mr. Hartley. The statements made in our Paper were based on actual experience and fact, and we still insist that we presented facts, not supposition.

However, we do think that the higher we rise the higher is our horizon, so the more we know, the more we see to be known. We would, therefore, welcome Mr. Hartley's theories and experience as to the correct method and material which will enable us to make better castings without feeding.—Yours, etc.,

E. W. WYNN AND D. F. HOPE.
Audley Engineering Company, Limited,
Newport, Shropshire.

December 1, 1936.

Company Reports

John Harper & Company, Limited.—Interim dividend of 3 per cent. on the ordinary shares.

Hoffmann Manufacturing Company, Limited.—Payment of debenture interest and preference dividend for six months ended December 31, 1936.

Broom & Wade, Limited.—Trading profit for year ended September 30, £36,718; dividend receivable from subsidiary, £7,401; brought in, £3,633; income tax, £1,500; employees' bonus, £1,750; directors' additional remuneration, £5,546; final dividend of 15 per cent. on the ordinary shares, making 20 per cent. actual on the original issue; carried forward, after preference dividend, £9,272.

Hepworth & Grandage, Limited.—Profit for year to September 30, after charging all expenses, including depreciation and maintenance of plant, £42,914; brought in, £21,972; fees, £1,431; reorganisation expenses (instalment), £2,000; income tax, £5,372; dividend of 12½ per cent. for the year, £21,875; bonus distribution of 2½ per cent., £4,375; to general reserve, £9,000; carried forward, £20,833.

Contracts Open

Southport, December 15.—3-in. to 6-in. dia. cast-iron pipes and specials, for the Southport and District Water Board. The Engineer and Manager, 14, Portland Street, Southport. (Fee £1, returnable.)

Wellington, January 26.—Five-ton two-motor gantry crane with auxiliary hoist, for the New Zealand Public Works Department. The Department of Overseas Trade. (Reference T.Y. 2,167.)

Personal

MR. R. GRAY relinquished his position of general works manager at Dorman, Long & Company's Redcar Works at the end of November.

MR. F. E. REBBECK, of Harland & Wolff, Limited, Belfast, has been elected President of the Shipbuilding Employers' Federation, in succession to Sir Maurice Denny.

MR. G. L. PARSONS has been appointed chairman of the Parsons Marine Steam Turbine Company, Limited, of Wallsend-on-Tyne, and MR. W. H. PILMOUR has been appointed managing director to succeed the late Mr. R. J. Walker.

SIR HARRY MCGOWAN, chairman of Imperial Chemical Industries, Limited, on behalf of the company, has offered to give £10,000 towards the cost of the new chemistry research buildings of Glasgow University.

Will

FLAVELL, WALTER JOSEPH, of W. J. Flavell & Company, patternmakers, of Wolverhampton	£4,032

Obituary

THE DEATH OCCURRED last Thursday of Mr. William T. Chambers, a director of the Motherwell Foundry Company, Limited.

THE DEATH OCCURRED last week of Mr. Michael J. Whitehouse, formerly managing director of John Bagnall & Sons, Limited, Lea Brook Ironworks, Wednesbury. He was 89 years of age.

MR. WILLIAM TAYLOR, who recently died in his 89th year, was the son of the founder of Taylor Bros. (Sandiacre), Limited, railway engineers and ironfounders. Mr. Taylor retired in 1912.

MR. ALEXANDER FYFE, who was associated practically all his life with Craig & Donald, Limited, machine-tool makers, Johnstone, Glasgow, has died. He retired about eight years ago and gave up his directorship of the company about five years ago.

MR. ALBERT HENRY IVEY, of Bristol, assistant works director of the National Smelting Company, Limited, and formerly works manager of the Swansea Vale Spelter Works, Llansamlet, died recently. Mr. Ivey has been associated with the Swansea Vale Works for 20 years, and was works manager from 1921 until 1927, when he left for the Avonmouth works.

LT.-COL. BENJAMIN PALIN DOBSON died on November 26, aged 58. He entered the family business of Dobson & Barlow, Limited, the textile machinery manufacturers and ironfounders, of Bolton, on leaving school, and was actively associated with the management of the works until the firm became merged in Textile Machinery Makers, Limited. He retired from active business in 1933.

Forthcoming Events

Institute of British Foundrymen

DECEMBER 12.

East Midlands Branch:—"Patterns and their Relation to Moulding Problems," Paper by S. A. Horton, at Loughborough College, Loughborough, at 6 p.m.

Scottish Branch:—"Mould and Core Drying," Paper by W. H. Smith; Annual Dinner at the Grosvenor Restaurant, Glasgow.

West Riding of Yorkshire:—Works visit to Greenwood & Batley, Limited, Leeds.

DECEMBER 18.

Middlesbrough Branch:—"Plate and Machine Moulding for Repetition Castings," Paper by J. Pell, at the Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, at 7.45 p.m.

DECEMBER 19.

Lincolnshire Section:—"Moulding Pumps without Patterns," Paper by F. F. Mather, at the Technical College, Monks Road, Lincoln, at 7 p.m.

Newcastle-upon-Tyne Branch:—Joint meeting with Institute of Metals and Coke Oven Managers' Association: "Refractories for Foundry Purposes," Paper by P. B. Robinson, M.Met., at the Neville Hall, Westgate Road, Newcastle-upon-Tyne, at 6.15 p.m.

DECEMBER 21.

Falkirk Section:—"Developments in the Production of Ingot Mould Castings," Paper by R. Ballantine, at the Temperance Café, Lint Riggs, Falkirk, at 7.15 p.m.

The Institute of Vitreous Enamellers

DECEMBER 17.

Scottish Section:—"Enamels for Wet-Coating Cast Iron," Paper by J. G. Keith, at the Royal Technical College, Glasgow, at 7.30 p.m.

Have you tried

RIXONS (W'BRO')

FOUNDRY PIG IRON?

Rixons (W'bro') is a Northamptonshire iron which gives economy with reliability, and is particularly suitable for electrical castings, light pipes, rainwater goods, builders' hardware, stoves, grates, road-signs, manholes and similar products. It is produced solely for the open market.

Full analyses of Rixons (W'bro') Foundry Pig Irons, together with much data of use to the foundryman, are included in our Pig Iron Handbook which we shall be pleased to send on request.

Individual foundry problems are dealt with by our Metallurgical Service Department, and if required, a qualified metallurgist will visit your works for a personal consultation.

The Stanton Ironworks Company Limited, near Nottingham.

The Largest Producers of Foundry Pig Iron (for sale) in Great Britain

Raw Material Markets

If anything, rather quieter conditions appear to have ruled during the past week, as, with the approach of the Christmas vacation and the knowledge that supplies of pig-iron in most areas are difficult to obtain except under existing contracts, consumers have been content to await the turn of the year. The effect of the revised prices will not be fully felt until after March, most consumers being fully covered by contract over the next few months.

Pig-Iron

MIDDLESBROUGH.—Judging by recent activity it would appear that consumers had decided to remain out of the market until after the end of the year, for the past week has seen little evidence of anxiety to enter into new business. Undoubtedly the desire is there, but until the supply position improves there is little hope of securing further tonnages. No. 3 Cleveland G.M.B. is now quoted at 81s. per ton in the Middlesbrough area, 83s. for other destinations on the North-East Coast, 84s. in Falkirk, and 87s. in Glasgow. It is stated that home consumers will receive adequate supplies and that the prices will not be again altered until the end of June, 1937.

While no change has been announced with regard to hematite prices, it is almost certain that higher figures will rule in the near future. Costs of production have risen enormously and undoubtedly the burden will have to be passed on to the consumer. No new business is reported. The quotation for deliveries on the North-East Coast is 85s. per ton, less 5s. rebate, but this is, of course, merely nominal.

LANCASHIRE.—New business is restricted to the first half of next year, but there has been a pronounced decline in the number of inquiries during the past week. Deliveries have been maintained on a heavy scale to the light-castings, heavy electrical engineering, machine-tool and the jobbing sections of the trade. Staffordshire and Derbyshire brands of No. 3 foundry iron are quoted at 89s., for delivery in the Lancashire price zone, with Northants at 87s. 6d., and Derbyshire forge iron at from 84s. to 86s. The values of East and West Coast hematite are unchanged and nominal at recent levels.

MIDLANDS.—There has been no decline in the demand from the ironfoundries for deliveries of pig-iron, and the supply position remains an acute problem. The recently revised prices are 86s. for Derbyshire, Lincolnshire and North Staffordshire No. 3, and 83s. 6d. for Northamptonshire No. 3, delivered Birmingham and Black Country stations, and subject to an extra of 11d. per ton for delivery into works. Following the advances made in the prices of common irons, quotations for the special grades have risen, and are now as follow :—Medium-phosphorus iron, 90s. to 95s.; low-phosphorus, including Scottish, 95s. to 105s.; refined iron, £6 5s. to £7 10s. The price of the latter has not been changed. Consumers of hematite are keen to procure supplies, but material is unobtainable at the present. West Coast mixed numbers are quoted at £4 17s.. East Coast No. 3 at £4 16s., and Welsh mixed numbers at £4 15s. 6d., delivered the Midlands.

SCOTLAND.—There is a heavy inquiry for pig-iron in this area, but new business is rarely placed owing to the severe shortage of supplies. The official minimum price has now been raised 9s. to 88s. f.o.t. furnaces, with 2s. 6d. extra for No. 1. Cleveland No. 3 is now at 84s. f.o.t. Falkirk and 87s. f.o.t. Glasgow, but these figures are purely nominal, as there is no material available. It is reported that supplies of basic iron are more free, but the position as to hematite is unaltered. Mixed numbers of East Coast, West Coast and Scottish hematite are still quoted at 85s. 6d., less 5s. rebate, while British and India basic are at 75s., less 5s. rebate, all delivered f.o.t. steelworks.

Coke

There is no further alteration to report in the prices of foundry coke, which are very firm. However, indications point to additional increases being made in the near future, and it is reported that some collieries have already warned their consumers to this effect. For delivery in Birmingham and district, best Durham coke is quoted between 42s. 6d. and 45s., with Welsh from 41s. 6d. to 54s. per ton.

Steel

No improvement has occurred in the stringent conditions which have ruled in the steel market for many weeks, states the official report of the London Iron and Steel Exchange. While it is expected that some relief will be afforded by the release of the Continental quota of steel which has just been made, it is not likely that the quantity will be sufficient to affect the situation to any extent in view of the extraordinarily heavy demand. In the semi-finished steel department most of the British works have sold their production for several weeks to come and it is not easy to place contracts for anything like near delivery. The demand for finished steel shows no signs of declining and recent orders for new ships and extensions to factories and workshops will increase the requirements of the market in the not distant future. There is little surplus left for export after the home demand has been dealt with. Tightness is apparent in the market for Continental steel for overseas destinations and prices this week have been substantially increased.

Scrap

Quotations for scrap on the Cleveland market are unchanged, but in view of the very firm conditions that are at present prevailing, higher prices are likely to rule in the near future. The demand is very strong for nearly all descriptions. Heavy steel scrap is at 60s. per ton, while machinery metal is quickly taken up at 67s. 6d., with heavy foundry cast iron at 65s. Light metal is available in small tonnages only at 53s. There has been no relaxation in the demand on the Midland market, all qualities being well taken up. Heavy steel in furnace sizes is at 53s. 6d. to 55s., with mixed heavy iron and steel at 1s. per ton less. Heavy wrought iron is at 65s. to 67s. 6d. Heavy machinery in handy sizes is at 72s. 6d., while 67s. 6d. is paid for good heavy, and 55s. for clean light metal. Short, heavy, steel scrap, as used in the foundries, is at 65s. to 67s. 6d. per ton, delivered works. Business is very active on the Yorkshire market and recent transactions have involved substantial tonnages. The price of foundry cast iron is now around 70s., while there is a fair demand for steelworks heavy cast iron at 55s. Heavy wrought iron, suitable for shearing, is active at around 67s. 6d. Heavy, basic melting steel receives a good inquiry at 60s. to 62s. 6d. A brisk inquiry is experienced on the Scottish market. Heavy steel scrap in furnace sizes is at 57s. 6d., with heavy basic, or heavy iron and steel scrap mixed, at 52s. 6d. Rough and small wrought iron is 67s. 6d., with shovelling quality 5s. less. Heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., is around 72s. 6d., with heavy ordinary cast iron, to the same specification, 65s. to 66s. 6d. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—Although industrial demand has been on a reduced scale this week, the firm tone of the market is well maintained and the decline is of a seasonal nature only. Large tonnages are being taken up by Scandinavia, but French and German interest is below expectations. Most users in the United States are well covered, but a satisfactory demand is still experienced. Japan continues to be a heavy buyer of refined metal.

Daily market prices :—

Cash.—Thursday, £43 8s. 9d. to £43 11s. 3d.; Friday, £43 8s. 9d. to £43 11s. 3d.; Monday, £43 15s. to £43 17s. 6d.; Tuesday, £44 7s. 6d. to £44 8s. 9d.; Wednesday, £44 7s. 6d. to £44 10s.

Three Months.—Thursday, £43 16s. 3d. to £43 17s. 6d.; Friday, £43 16s. 3d. to £43 17s. 6d.; Monday, £44 2s. 6d. to £44 3s. 9d.; Tuesday, £44 12s. 6d. to £44 15s.; Wednesday, £44 13s. 9d. to £44 16s. 3d.

Tin.—The November tin statistics revealed a much larger increase in the visible supply than had been expected. This was chiefly due to the abnormally high Straits shipments. According to the statistics issued by Mr. W. H. Gartsen (Henry Rogers, Sons & Company), the total visible supply of tin at the end of November was 18,264 tons, as compared with 13,327 tons on October 31. The carry-over in the Straits Settlements was 2,939 tons, against 3,688 tons, while the carry-over at the Arnhem (Holland) smelter was 934 tons, against 960 tons. During the past week trade demand has not been very substantial, although consumption is reported to be well maintained. In the United States, industrial dealings are heavy and particular note should be taken of the very high rate of activity at the tinplate mills. Meanwhile, the tin market continues to be affected by the uncertainties of the world political situation and forecasts of future prospects are not easily made. It is reported from Batavia that the Bill providing for the merger between the Banka and Billiton tin enterprises has been drawn up by the Dutch Department of the Colonies.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £229 to £229 5s.; Friday, £226 to £226 5s.; Monday, £227 to £227 10s.; Tuesday, £228 10s. to £228 12s. 6d.; Wednesday, £231 10s. to £231 15s.

Three Months.—Thursday, £228 15s. to £229; Friday, £226 to £226 5s.; Monday, £227 to £227 10s.; Tuesday, £228 10s. to £228 12s. 6d.; Wednesday, £231 10s. to £231 15s.

Spelter.—Featureless conditions continue to rule on this market and the outlook is uncertain. Production is undoubtedly on much too high a scale to allow the market to settle down to any state of normality and remains far in excess of consumption.

Official quotations were as follow :—

Ordinary. — Thursday, £16 5s.; Friday, £16 2s. 6d.; Monday, £16 5s.; Tuesday, £16 5s.; Wednesday, £17.

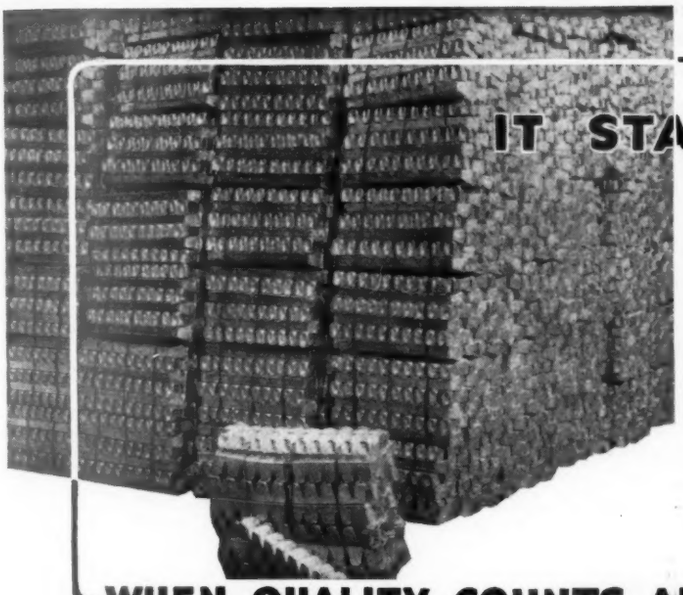
Lead.—Some fairly good tonnages have been involved in the past week's business, and the market generally displays a steady tone. With the Christmas vacation in the offing, industry will be interrupted for a few days, but a resumption will not be long delayed. There has been a decline in trade demand in the United States, but here, again, the change is only of a seasonal nature.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £22 12s. 6d.; Friday, £22 12s. 6d.; Monday, £22 17s. 6d.; Tuesday, £23 7s. 6d.; Wednesday, £24 1s. 3d.

WHEN THINKING OF
SANDBLAST
THINK OF
RICHARDSON'S
Established 1887.
We Supply Re-Conditioned & New
SAND BLAST PLANTS
AND
AIR COMPRESSORS.
Tilghman's, Room, Barrel, Chamber, Rotary Table, Dust Arrester, and Continuous Feed Barrel Plants.
Phone: MIDLAND 2281.
Grams: "SANDBLAST, B'HAM."
R. J. RICHARDSON & SONS, Ltd.,
Commercial Street, Birmingham.

SUPERIOR SILICA BRICKS
FINE SILICA CEMENT.
TRADE MARK—R. DINAS.
SMARTS DINAS SILICA BRICK Co., Ltd.,
KIDWELLY.



IT STANDS TO REASON!

Remelted metal cannot be so free from contaminating oxide or dissolved gases as virgin metal.

Such contaminations cannot be detected by ordinary analysis, but they have a profound effect on the quality of the casting.

WHEN QUALITY COUNTS ALWAYS USE VIRGIN METAL

The BRITISH ALUMINIUM Co.Ltd.

HEAD OFFICE: ADELAIDE HOUSE, KING WILLIAM STREET, LONDON, E.C.4.

Telephone: Mansion House 5561 & 8074 (6 lines). Telegrams: CRYOLITE, BILGATE, LONDON

LONDON WAREHOUSE: 25-29 Pancras Road N.W.1 — BIRMINGHAM, 4: Lawley Street — MANCHESTER, 3: 274 Deansgate — LEEDS, 3: 66 Kirkstall Road — BRISTOL, 1: Rose St., Temple — NEWCASTLE-ON-TYNE, 1: Milburn House — GLASGOW, C.2: 113 West Regent St

AND AT TORONTO, MONTREAL, CALCUTTA, SYDNEY, AND JOHANNESBURG

The B.A. Co. produce virgin ingots of pure metal and alloys made only of virgin metals.

F.T.J. 10-12-36.

WARNER Special PIG IRONS

- Warner C.B.R. and Low Carbon Cylinder (FOR CYLINDERS, ROLLS, ENGINEERING CASTINGS, ETC.)
- Low Carbon Malleable (FOR MALLEABLE CASTINGS OF ALL DESCRIPTIONS)

Supplied to any specification between limits of 2·00 and 3·50% Carbon and ·50% and 3·50% Silicon

ACTUAL ANALYSIS CERTIFICATES ARE AVAILABLE WITH EACH DELIVERY

Typical Cylinder Pig Iron Specification

TOTAL CARBON	2·70%
SILICON	1·80%
MANGANESE	·90%
SULPHUR	·06%
PHOSPHORUS	·40%

Typical Malleable Pig Iron Specification

TOTAL CARBON	2·60%
SILICON	·75%
MANGANESE	·50%
SULPHUR	·05%
PHOSPHORUS	·06%

WARNER & CO., LTD
CARGO FLEET · MIDDLESBROUGH

RAW MATERIALS—PRICE LIST

(Wednesday, December 9, 1936)

COPPER

	£	s.	d.
Standard cash	44	7	6
Three months	44	13	9
Electrolytic	48	15	0
Tough	47	5	0
Best selected	47	15	0
Sheets	77	0	0
India	57	15	0
Wire bars	49	0	0
Ingot bars	49	0	0
H.C. wire rods	52	10	0
Off. av. cash, Nov.	43	19	5 1/2
Do., 3 mths., Nov.	44	6	7 9/16
Do., Sttlmnt., Nov.	43	19	7 1/2
Do., Electro, Nov.	48	14	6 9/16
Do., B.S., Nov.	48	8	1 1/2
Do., wire bars, Nov.	48	19	9 1/4
Solid drawn tubes			11 1/4d.
Brazed tubes			11 1/4d.
Wire			7 1/4d.

BRASS

Solid drawn tubes	10 1/2d.
Brazed tubes	12 1/2d.
Rods, drawn	9 1/2d.
Rods, extd. or rlld.	5 1/2d.
Sheets to 10 w.g.	8 1/2d.
Wire	8 1/2d.
Rolled metal	8 1/2d.
Yellow metal rods	5 1/2d.

TIN

	£	s.	d.
Standard cash	231	10	0
Three months	231	10	0
English	231	10	0
Bars	233	10	0
Straits	233	10	0
Australian	231	10	0
Eastern	232	15	0
Banca (nom.)	233	10	0
Off. av. cash, Nov.	231	0	11 3/4
Do., 3 mths., Nov.	229	5	10
Do., Sttlmt., Nov.	231	0	11 3/4

SPELTER

	£	s.	d.
Ordinary	17	0	0
Remelted	14	10	0
Hard	13	10	0
Electro 99.9	19	1	3
English	17	0	0
India	14	5	0
Zinc dust	20	10	0
Zinc ashes	4	15	0
Off. aver., Nov.	16	8	6 1/4
Aver. spot, Nov.	16	6	0 3/4

LEAD

	£	s.	d.
Soft foreign ppt.	24	1	3
Empire	24	2	6
English	26	0	0
Off. aver., Nov.	21	14	2
Aver. spot, Nov.	21	14	5 3/4

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English	26	5	0	to	26	15	0
Do., V.M. ex-whse.	26	5	0	to	26	15	0
Rods					28	5	0

ANTIMONY

English	67	10	0	to	68	10	0
Chinese, ex-whse.					54	0	0
Crude, c.i.f.					26	0	0

QUICKSILVER

Quicksilver	14	0	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—							
25%					8	17	6
45/50%	11	0	0	to	12	5	0
75%	16	2	6	to	17	7	6
Ferro-vanadium—							
35/50%					12/8 lb. Va.		
Ferro-molybdenum—							
70/75% carbon-free					4/6 lb. Mo.		
Ferro-titanium—							
20/25% carbon-free					9d. lb.		
Ferro-phosphorus, 20/25%					£21 to £22		
Ferro-tungsten—							
80/85%					3/1 1/2 lb.		
Tungsten metal powder—							
98/99%					3/3 lb.		
Ferro-chrome—							
2/4% car.					33	0	0
4/6% car.					21	10	0
6/8% car.					21	0	0
8/10% car.					21	0	0
Ferro-chrome—							
Max. 2% car.					33	10	0
Max. 1% car.					36	5	0
Max. 0.5% car.					37	5	0
70% carbon-free					9 1/2d. lb.		
Nickel—99.5/100%					£200 to £205		
"F" nickel shot					£184	0	0
Ferro-cobalt, 98/99%					7/3 lb.		
Metallic chromium—							
96/98%					2/5 lb.		
Ferro-manganese—							
76/80% loose	£11	15	0	to	12	5	0
76/80% packed	£12	15	0	to	13	5	0
76/80% export					£10	15	0
Metallic manganese—							
94/96% carbon-free					1/3 lb.		

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/4 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 3/16 in.	1/- lb.
Flats, 1/4 in. × 1/4 in. to under 1 in. × 3/8 in.	3d. lb.
Do., under 1/4 in. × 1/4 in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.		£	s.	d.
South Wales—							
Heavy steel					3	4	0
Mixed iron and steel	3	0	0	to	3	1	0
Heavy cast iron	2	18	0	to	3	0	0
Good machinery	3	2	0	to	3	4	0
Cleveland—							
Heavy steel					3	0	0
Steel turnings					2	5	0
Heavy cast iron					3	5	0
Heavy machinery					3	7	6
Midlands—							
Light cast-iron scrap					2	15	0
Heavy wrought iron	3	5	0	to	3	7	6
Steel turnings					2	0	0
Scotland—							
Heavy steel					2	17	6
Ordinary cast iron	3	5	0	to	3	6	6
Engineers' turnings					2	2	6
Cast-iron borings					1	18	0
Wrot-iron piling					3	10	0
Heavy machinery					3	12	6

London—Merchants' buying prices, delivered yard.

Copper (clean)	37	0	0
Brass	22	0	0
Lead (less usual draft)	20	15	0
Tea lead	16	10	0
Zinc	9	10	0
New aluminium cuttings	74	0	0
Brasiery copper	34	0	0
Gunmetal	34	0	0
Hollow pewter	165	0	0
Shaped black pewter	122	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—

Foundry No. 1	83/6
" No. 3	81/-
" No. 4	80/-
Forge No. 4	80/-
Hematite No. 1	85/6*
Hematite M/Nos.	85/-*

N.W. Coast—

Hem. M/Nos. d/d Glas.	85/6*
" d/d Birm.	97/-*
Malleable iron d/d Birm.	125/-

Midlands (d/d Birmingham dist.)—

Staffs No. 4 forge	83/-
" No. 3 fdry.	86/-
Northants forge	80/6
" fdry. No. 3	83/6
" fdry. No. 1	86/6
Derbyshire forge	83/-
" fdry. No. 3	86/-
" fdry. No. 1	89/-

Scotland—

Foundry, No. 1, f.o.t.	90/6
" No. 3, f.o.t.	88/-
Cleveland No. 3, Glasgow	87/-
" Falkirk	84/-
Scottish hem. M/Nos. d/d	85/6*

Sheffield (d/d district)—

Derby forge	80/6
" fdry. No. 3	83/6
Lincs forge	80/6
" fdry. No. 3	83/6
W.C. hematite	91/-*

Lancashire (d/d eq. Man.)—

Derby fdry. No. 3	89/-
Staffs fdry. No. 3	89/-
Northants fdry. No. 3	87/6
Cleveland fdry. No. 3	89/-
Glengarnock, No. 3	102/6
Clyde, No. 3	102/6
Monkland, No. 3	102/6
Summerlee, No. 3	102/6
Eglinton, No. 3	102/6
Gartsherrie, No. 3	102/6
Shotts, No. 3	102/6

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.		£	s.	d.
Bars (cr.)					10	10	0
Nut and bolt iron	8	17	6	to	9	7	6
Hoops			11	7	6	and up.	
Marked bars (Staffs) f.o.t.					13	0	0
Gas strip			11	7	6	and up.	
Bolts and nuts, 1/4 in. × 4 in.					16	0	0 and up.
Steel—							
Plates, ship, etc.	9	7	6	to	9	10	0
Boiler plts.	9	17	6	to	10	0	0
Chequer plts.					11	0	0
Angles					9	0	0
Tees					10	0	0
Joists					9	7	6
Rounds and squares, 3 in. to 5/8 in.					10	0	0
Rounds under 3 in. to 1/4 in. (Untested)					9	7	0
Flats—8 in. wide and over					9	5	0
" under 8 in. and over 5 in.					9	10	0
Rails, heavy	8	5	0	to	8	10	0
Fishplates					12	10	0
Hoops (Staffs)					10	2	0
Black sheets, 24g. (4-t. lots)					12	0	0
Galv. cor. shts. (")					14	0	0
Galv. flat shts. (")					14	10	0
Galv. fencing wire, 8g. plain					15	0	0
Billets, soft					6	2	6
Billets, hard	7	2	6	to	7	7	6
Sheet bars					6	0	0
Tin bars					6	0	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	11d.
Sheet to 10 w.g.	12d.
Wire	13 1/2d.
Rods	12 3/4d.
Tubes	14 1/2d.
Castings	12 1/2d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1 1/2 to 1/7 1/2
To 15 in. wide	1/1 1/2 to 1/7 1/2
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2 1/2 to 1/8 1/2
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3 1/2
Ingots rolled to spoon size	10d. to 1/6 1/2
Wire round—	
to 10g.	1/4 1/2 to 1/11 1/2

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3 1/2 upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.88
Basic, Valley	1[illegible].00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37 1/2
Billets	32.00
Sheet bars	32.00
Wire rods	40.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	2.05
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.60
Sheets, galv., No. 24	3.20
Wire nails	2.05
Plain wire	2.50
Barbed wire, galv.	2.55
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/- to 32/6
" furnace	24/6 to 25/-
Durham foundry	24/6
" furnace	21/6
Scotland, foundry	30/-
" furnace	25/- to 26/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box		18/9 to 19/3
"	28×20	"	37/6 to 38/-
"	20×10	"	27/- to 27/6
"	18 3/4×14	"	19/6 to 19/9
C.W.	20×14	"	16/- to 16/6
"	28×20	"	34/6 to 35/-
"	20×10	"	23/3 to 23/6
"	18 3/4×14	"	16/6

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6	0	0	to	£7	0	0
Bars-hammered, basis	£16	0	0	to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0	to	£16	0	0
Blooms	£10	0	0	to	£12	0	0
Keg steel	£25	0	0	to	£28	0	0
Faggot steel	£18	0	0	to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0	to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£ s. d.	
Dec. 3 ..	43 8 9	inc. 2/6
,, 4 ..	43 8 9	No change
,, 7 ..	43 15 0	inc. 6/3
,, 8 ..	44 7 6	,, 12/6
,, 9 ..	44 7 6	No change

Electrolytic Copper

	£ s. d.	
Dec. 3 ..	47 15 0	dec. 5/-
,, 4 ..	47 15 0	No change
,, 7 ..	48 0 0	inc. 5/-
,, 8 ..	48 15 0	,, 15/-
,, 9 ..	48 15 0	No change

Standard Tin (cash)

	£ s. d.	
Dec. 3 ..	229 0 0	dec. 45/-
,, 4 ..	226 0 0	,, 60/-
,, 7 ..	227 0 0	inc. 20/-
,, 8 ..	228 10 0	,, 30/-
,, 9 ..	231 10 0	,, 60/-

Tin (English ingots)

	£ s. d.	
Dec. 3 ..	229 5 0	dec. 45/-
,, 4 ..	226 5 0	,, 60/-
,, 7 ..	227 10 0	inc. 25/-
,, 8 ..	228 10 0	,, 30/-
,, 9 ..	231 10 0	,, 60/-

Spelter (ordinary)

	£ s. d.	
Dec. 3 ..	16 5 0	No change
,, 4 ..	16 2 6	dec. 2/6
,, 7 ..	16 5 0	inc. 2/6
,, 8 ..	16 5 0	No change
,, 9 ..	17 0 0	inc. 15/-

Spelter (Electro, 99.9 per cent.)

	£ s. d.	
Dec. 3 ..	18 5 0	dec. 1/3
,, 4 ..	18 3 9	,, 1/3
,, 7 ..	18 5 0	inc. 1/3
,, 8 ..	18 6 3	,, 1/3
,, 9 ..	19 1 3	,, 15/-

Lead (soft foreign, prompt)

	£ s. d.	
Dec. 3 ..	22 12 6	dec. 2/6
,, 4 ..	22 12 6	No change
,, 7 ..	22 17 6	inc. 5/-
,, 8 ..	23 7 6	,, 10/-
,, 9 ..	24 1 3	,, 13/9

Lead (English)

	£ s. d.	
Dec. 3 ..	24 15 0	No change
,, 4 ..	24 15 0	,, ,,
,, 7 ..	24 15 0	,, ,,
,, 8 ..	25 5 0	inc. 10/-
,, 9 ..	26 0 0	,, 15/-

A COMPARISON OF SCRAP PRICES

Average Monthly Prices of Cast-Iron Scrap in the Principal Districts in the Years 1930–36

SCOTLAND (Heavy Machinery)—

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1930..	3 10 0	3 9 6	3 8 6	3 8 3	3 8 1	3 5 9	3 3 2	3 3 4	3 3 0	3 0 9	2 19 4	2 17 8	3 4 9
1931..	2 15 0	2 15 0	2 13 3	2 10 8	2 9 9	2 8 3	2 8 6	2 7 9	2 5 6	2 9 8	2 14 5	2 15 9	2 11 2
1932..	2 15 0	2 15 0	2 12 6	2 10 6	2 7 6	2 5 3	2 4 5	2 3 10	2 4 10	2 4 4	2 4 0	2 4 8	2 7 8
1933..	2 7 0	2 9 3	2 10 8	2 10 5	2 9 5	2 9 3	2 8 6	2 10 9	2 10 4	2 10 7	2 10 10	2 12 4	2 9 11
1934..	2 14 2	2 17 9	2 18 5	2 18 3	2 15 5	2 15 9	2 14 3	2 15 0	2 15 9	2 15 0	2 15 8	2 16 3	2 16 0
1935..	2 15 5	2 15 8	2 15 10	2 16 4	2 16 10	2 17 0	2 16 9	2 16 9	2 17 0	2 16 11	2 19 11	3 2 7	2 17 5
1936..	3 4 8	3 9 10	3 11 10	3 11 10	3 10 8	3 9 10	3 9 2	3 8 9	3 8 11	3 9 2	3 9 7	—	—

N.E. COAST (Heavy Qualities)—

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1930..	3 4 6	3 4 1	3 3 3	3 2 6	3 0 5	2 19 5	2 17 9	2 16 3	2 16 3	2 13 4	2 6 6	2 11 9	2 18 6
1931..	2 10 4	3 9 8	2 9 7	2 8 3	2 6 3	2 3 8	2 2 9	2 1 9	2 1 0	2 2 1	2 9 9	2 6 6	2 5 11
1932..	2 6 3	2 5 8	2 3 0	2 0 8	1 19 0	2 1 0	1 15 9	1 15 6	1 15 6	1 15 6	1 17 4	1 19 10	1 19 7
1933..	2 1 1	2 2 2	2 4 9	2 3 5	1 18 9	1 19 6	2 0 0	2 0 0	2 1 3	2 5 8	2 7 10	2 10 1	2 5 4
1934..	2 12 7	2 15 1	2 13 7	2 11 6	2 11 11	2 13 9	2 11 0	2 10 6	2 11 3	2 11 10	2 13 9	2 13 3	2 12 4
1935..	2 12 2	2 13 0	2 12 7	2 13 0	2 12 9	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 16 10	2 12 10
1936..	3 0 0	3 1 10	3 1 8	3 2 2	3 4 6	3 3 9	3 5 9	3 4 1	3 5 11	3 6 3	3 6 3	—	—

S. WALES (Heavy Cast Iron)—

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1930..	3 18 5	3 18 9	2 19 0	2 18 8	2 17 2	2 16 2	2 14 8	2 13 10	2 14 1	2 12 7	2 8 5	2 5 11	2 14 0
1931..	2 7 7	2 8 3	2 9 9	2 8 1	2 6 11	2 5 2	2 2 9	2 2 2	2 0 11	2 3 9	2 7 6	2 7 10	2 5 9
1932..	2 7 2	2 6 8	2 6 4	2 5 0	2 4 8	2 0 8	1 19 4	2 1 7	2 1 10	1 18 10	1 19 8	2 2 1	2 2 0
1933..	2 3 4	2 4 6	2 4 6	2 4 1	2 3 5	2 2 8	2 3 7	2 4 8	2 5 8	2 5 9	2 5 7	2 5 0	2 4 5
1934..	2 6 10	2 8 9	2 7 8	2 6 6	2 7 6	2 8 0	2 6 10	2 6 7	2 8 0	2 8 2	2 9 1	2 11 5	2 7 1
1935..	2 11 3	2 11 4	2 11 1	2 11 3	2 12 0	2 11 1	2 11 1	2 11 0	2 12 2	2 13 10	2 14 5	2 14 8	2 11 9
1936..	2 16 3	2 18 7	2 18 9	2 19 2	2 18 7	2 18 7	2 19 0	2 19 0	2 18 9	2 19 0	2 19 2	—	—

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK

LIMPET

FOR EVERY TYPE OF CASTING

NON-FERROUS METALS

REFRACTORIES — COKE — SAND

FERRO-SILICON—FERRO-CHROME

WILLIAM JACKS & COMPANY,

CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.

ZETLAND ROAD, MIDDLESBROUGH.

SITUATIONS VACANT AND WANTED

FOUNDRY CLERK required, age over 25. State experience and salary required.—Box 112, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

REQUIRED by oversea industrial concern, a competent Works Manager, fully versed in manufacture of graphite crucibles, to build up a factory and manage it.—Reply Box 108, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

REPRESENTATIVE for well-known firm of ironfounders specialising in road and sewerage ironwork. Connection with municipal authorities essential. Write in confidence stating experience and salary required.—Box 128, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—General Foundry Foreman fully versed in green sand moulding, for small foundry in the South; output approximately 20 tons weekly; must be able to fix piecework prices.—Box 134, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Foundry Manager for foundry producing principally grey iron, but also ferrous alloys. The position is progressive: the foundry was rebuilt only two years ago and is very well equipped, forming an attractive proposition for a competent up-to-date man on the lookout for good healthy surroundings. Output 200 tons per month of small castings. Applicants state training, type of work on which experience has been gained, and full qualifications to Box 132, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

PATENT

THE proprietor of British Patent No. 399,475, dated March 31, 1932 (Convention Date May 4, 1931), for "Improvements relating to the reduction of ore," is desirous of entering into arrangements by way of a licence or otherwise on reasonable terms for the purpose of exploiting the above patent and ensuring its practical working in Great Britain. Inquiries to MR. B. SINGER, Chrysler Building, New York City, N.Y., U.S.A.

TENDER

GREAT WESTERN RAILWAY.

THE Directors of this Company are prepared to receive Tenders for the supply from February 1, 1937, of the undermentioned Iron and Steel Goods:—

3.—Tyres and Rolled Steel Wheel Centres.
4.—Steel Axles and Forgings.
5.—Iron Bars and Plates.
6.—Steel Sheets.
7.—Steel Bars and Blooms.
8.—Steel Castings (Wheel Centres).
9.—Steel Castings (Miscellaneous).
11.—Chain.
12.—Tubes and Fittings. (Gas, Steam, Electric Conduit, etc.)
13.—Weldless Steel Tubes (Steam and H.P. Gas—Cold Finish).
14.—Iron Castings, Pipes, etc.
15.—Galvanised Sheets.

Specifications and Forms of Tender (upon which alone Tenders will be received) may be obtained on application to the Stores Superintendent at Swindon.

Tenders addressed to the undersigned and marked outside "Tender for Iron and Steel," will be received not later than 10 a.m. on Thursday, December 31, 1936.

The Directors do not bind themselves to accept the lowest or any Tender.

F. R. E. DAVIS,
Secretary.

Paddington Station,
London, W.2.
December 8, 1936.

BUSINESS FOR SALE

IRON FOUNDRY FOR SALE.

A PROFIT-EARNING old-established Iron Foundry Business for disposal. Accountant's figures available.—Apply REDDALL, OSBORNE & Co., 1, Guildhall Chambers, Basinghall Street, London, E.C.2.

MACHINERY

FOR Sale, Cheap. Two No. 0 and two No. 1 Britannia Jar Ram Pin-Lift Machines. Very little used.—Box 130, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOR SALE.—No. 7 Ajax Moulding Machine. Offers wanted.—Write: SIR JAMES FARMER NORTON & Co., LTD., Adelphi Ironworks, Salford, 3.

SAND MIXERS AND AERATORS.—The "Breakir" Centrifugal Machine is *THE* machine. Outputs 10 cwts. to 8 tons per hr.—W. BREALEY & Co., LTD., Station Works, Ecclesfield, Sheffield.

NEW No. 4 Climax Roots Blower, motor driven.
New No. 4 Sirocco Centrifugal Dust Fans.
New No. 0 Sturtevant Exhausting Fan.
New No. 2 Sturtevant Exhausting Fan.
Sirocco Exhausting Fan, 15-in. inlet.
New Grinding Wheels, 16 in. and 18 in. dia., 2-in. to 4-in. face.
10-cwt. Stacking Truck.
To be sold at reduced prices.
OLDFIELD,
82, North Western Street, Manchester, 12.

TABOR PNEUMATIC MOULDING MACHINES for sale. For price and particulars apply: WILCOX & Co. (B'HAM), LTD., 65-71, Barr Street, Birmingham, 19.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

Tilghman Sandblast Barrel Plants; barrel sizes—60 in. x 40 in.; 36 in. x 20 in.; 20 in. x 30 in.
Tilghman Sandblast Cabinet Plants; 4 ft. 6 in. and 3 ft. 6 in. square (one for high pressure 70 lbs. per sq. in.); also small Cabinet 30 in. dia.
All complete with Air Compressors, etc.
Gas and Air Mixer by Sharpe & Preston, 2-in. outlet.
Six Osborne Pneumatic Jolt Press Moulding Machines, size 75J.
Three Mumford Yoke Headpress Pneumatic Moulding Machines.
Two Herbert Whizzer Sand Disintegrators.
Two Brealey Type ditto.
Heavy Double-ended Grinding Machines by Rowlands, Luke & Spencer, etc.
Hand Moulding Machines by Adaptable Darling & Sellars, Pridmore, Samuelson, etc.
500 Electric Motors, Dynamos, Rotary Converters, etc.

S. C. BILSBY, A.M.I.C.E., A.M.I.E.E.
CROSSWELLS ROAD (Adjoining Railway Crossing), LANGLEY, Nr. Birmingham.
'Phone: Broadwell 1359.

THOS. W. WARD LTD.

Mumford Plain-type JOLTER by Jackman; 5′ sq. table; lifting capacity approximately 5,000 lbs.
Send for particulars of the Electrically-driven SAND RIDDLE.
Two MARINE BOILERS; 12′ 6″ x 10′ 6″; 120 lbs. w.p.
Galloway BOILER; 18′ 3″ x 7′ 3″; 80 lbs. w.p.

Write for "Albion" Catalogue.
'Grams: "Forward." 'Phone: 23001 (10 lines).
ALBION WORKS, SHEFFIELD.

MISCELLANEOUS

MODERN Brassfoundry is open to consider any class of casting up to 300 lbs. in phosphor bronze or gunmetal.—Address inquiries to: UNION BRASS WORKS, Brickfield Street, Hadfield, Manchester.

STEEL Moulding Boxes; 100 wanted; two parted 12 in. by 16 in. by 4 in. deep, top and bottom and 18¾ centres. State price and delivery to Box 120, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

QUEBEC YELLOW PINE. — H. R. HODGSON & Co., Importers, 94, Derby Road, Bootle, Liverpool.

GENUINE Southport Wind Blown Sand, which makes best oil-sand cores. Prompt deliveries by road into works.
JOHN LIVESEY,
SAND MERCHANT,
SOUTHPORT.

FINEST FOUNDRY BLACKINGS AND FACINGS. All our own productions by the latest machinery. Pure Ceylon Plumbago (import direct). Quality at reasonable prices. Orders are repeated Send for free sample.
JOHN & C. DURRANS,
PENNINE WORKS,
HAZLEHEAD, NEAR SHEFFIELD.
Telephone: 128 Penistone. Telegrams: "Facings, Penistone."

'Phone: 287 SLOUGH

MOULDING MACHINES

FOUR LATEST TYPE ADAPTABLE HAND MOULDING MACHINES. Price, £14 each.
SEVERAL NEARLY NEW UTARD POWER MOULDING MACHINES. Cheap.

New Brealey type Sand Mixer.	Price,	£25.
Sand Mill 4′ diameter, as new.	Price,	£22.
Large Herbert Sand Mixer.	Price,	£44.
Very good 18-ton Ladle.	Price	£40.

LARGE STOCK OF A.C. MOTORS, COMPRESSORS, SANDBLASTS, ETC.

PLEASE SEND US YOUR ENQUIRIES.

ALEX. HAMMOND, *Foundry Machinery Merchant.*
14, AUSTRALIA ROAD, SLOUGH
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